«Research to Practice»

Montréal 2012

Management of Construction

RESEARCH to PRACTICE

«Du savoir au Savoir-faire»

Joint CIB International Symposium of W055, W065, W089, W118, TG76, TG78, TG81 and TG84

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Volume 2

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FOREWORD

Welcome, everyone!

On behalf of the organizing committee for the 2012 CIB International Conference, it gives me great pleasure to welcome you all to Montreal, the largest French-speaking city in the Americas and, more recently, the capital of pots-and-pans street concerts greeting our guests with a unique joyful clanging!

The theme of this conference, Research to Practice, focuses on what is needed to meet the challenges of the ever-evolving building industry.

Societies are resolutely turning to energy efficiency, sustainability and increased harmony between people and their environment. The industry must cope with rapidly changing standards and client needs while being faced with productivity and cost control. Creativity is definitely key to this puzzle, which will be solved through a closer relationship and understanding between research and industry.

The Montreal conference is taking a step in this direction by adding an Industry Day to its program. On Thursday, June 28, participants from all aspects of construction, planning, managing and so on will gather with researchers to hear a distinguished panel of academics and industry experts share and discuss their views on research and the building industry and the importance of the link between the two.

Afternoon sessions will then provide everyone a chance to determine and define the most promising ways to successfully develop and transfer essential knowledge in the building field.

The organizing committee has endeavoured to provide participants with surroundings that will enhance learning and networking activities for Working Commissions W055, W065, W089 and W118.

I wish you all an enlightening conference and a pleasant stay in Montreal.

Serge Boileau

Conference Chair, MCRP 2012

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Construction Management Documentation using BIM

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Abstract

With Building Information Modeling / Management (BIM) being required by owners, how does everyone learn to use the information? The construction industry is now challenged to efficiently utilizing BIM and introducing construction professionals to new ways of thinking. We are not only talking about where the information is used, but in what format it is most efficiently documented and exchanged. In this paper, the authors present their experience at weaving BIM concepts throughout a construction management (CM) curriculum. The students are exposed to BIM at the graphics level in an introductory course where they learn to build the 3-D parametric model using Autodesk software. As an upper classmen, they apply technical knowledge to the model as away to manage construction documentation. Through exercises students understand their role as construction managers and establish procedures to document the construction processes within BIM. This paper includes examples of where information is documented in a BIM model and will highlight the details and courses involved in the process.

Keywords: BIM, Interdisciplinary approaches, construction management, construction visualization, computer graphics

1. Introduction

Students are constantly challenging instructors as to why they need to learn a topic and how the information is related to their career as a construction manager. At one Midwestern University, 4 year undergraduate program in Construction Management (CM) has begun to integrate Building Information Modeling / Management (BIM) across the curriculum. This integrates the 3D model with where the information is used, and in what format it is most efficiently documented and exchanged. In this paper, the authors present their experience at weaving the BIM concepts related to documentation of a project throughout a CM curriculum.

Many CM programs have documented their integration of BIM (Hyatt, 2011; Sabongi, 2009 & Taylor, Liu, & Hein, 2008). The construction industries, much driven by owners such as the US General Services Administration (GSA), are requiring BIM for project drawings, installation and facility services (General, 2006). The most current development in construction design is the ability to apply not only a three-dimensional representation of a building, but also attaching a database to the structure that would allow the tracking of schedule, cost, or specifications (Koo & Fischer 2000; Chau, Anson, & Zhang, 2004). BIM has the ability to detect clashes during the design process allowing better decision making to occur rather than costly rework during construction (Tanyer & Aoudad 2005).

The challenges in academia in weaving BIM into a curriculum are the balance of integrating technology while maintaining a high level of technical knowledge. Adding new courses is not feasible with restrictions on adding new resources. There are also discussions on how much a CM student needs to know about producing, manipulating, and interpreting a BIM model. One department has taken an integrated approach by introducing modules in courses across the curriculum to develop a layering of understanding how to develop and utilize a BIM model as a documentation tool for a construction manager.

2. Introductory Courses and BIM Modules

1.1. Introductory Courses

Students are introduced to BIM and the related software in a first year level computer graphics course. The course is taught with an emphasis on construction and civil engineering concepts. The final project for the course includes an interdisciplinary activity where students from computer graphics are paired with civil engineering and CM students. The CG students might be hired as the next BIM managers, building the expertise in BIM modeling, clash detection, and construction documentation. The construction students were observing the challenges of BIM modeling, getting involved in the process and working closely with the graphics students as the CM students have technical knowledge about the structure. The course was divided in 8 modules where the students were introduced to various concepts to better understand the goals, objectives, and benefits from having a BIM model. The concepts include:

1. Understand the settings and boundaries of the project

2. Apply BIM in the settings of an integrated practices project such as Design Build project

3. Understand the nuance between 3D modeling and Parametric modeling

4. Understand the various standards that control the software interoperability

5. Understand the concepts of object oriented programming and how it relates to lifecycle project information management

6. Understand the various roles of the participants

7. Understand the required documentation of work in progress

8. Leverage the BIM expertise towards the success of the construction project

The course uses Autodesk Revit Architectural 2010 for the Architectural model, Autodesk Revit structural 2010 for the Structural model and Autodesk Revit MEP Suite for the HVAC model. The class is required for all CM students and is usually taken during the first or second semester. It also serves to develop visualization skills that will be applied to plan reading and estimating courses. Different project are utilized each semester to keep the material in the class fresh and hinder the reuse of models developed in past semesters.

1.2. Introduction to Construction Management Module

Many students are taking an introductory course in construction management while they are learning the integration of software and tools to build the 3D parametric BIM model. The challenge is to assist the students in understanding the importance of the documentation of information related to the graphical representation of a project. The first assignment that the students are given is to tie the information about materials in the model to specifications. This is practiced by producing a spreadsheet in excel listing the materials which might be used on a commercial project. Using the Construction Specifications Institute (CSI) Masterformat divisions, student research one product for each division and prepare an excel spreadsheet to document that information. The information which is recorded in Microsoft Excel with columns:

1. CSI Masterformat division

2. Type of Material

3. Website of Product

4. Company name
5. Contact Information
6. Picture of product
7. Explanation of why it is Green, Sustainable or LEED points applicable

The assignment is given with the students gathering information which could be applied to a small commercial project. The individual assignment is graded and returned to be used for a group project to develop a 3D model of a small office area renovation. The students are applying knowledge, developing visuals, and documenting materials. The excel spreadsheet could then be linked to the 3D model and used to verify materials. This demonstrates the connection of the model to a specification. This is the students' first experience with connecting the model and technical information.

3. Upper level courses and BIM models

3.1 Concrete Module

Introducing BIM concepts and principles to the concrete class, is another aspect of the integration of BIM throughout the construction curriculum. Unlike engineering students who focus on the design and calculations aspects of concrete in the building, the construction management students focus on construction management practices related to documentation of construction activities in relation to cost, schedule and quality of work. Construction field personnel are required to track and document daily activities related to (1) submission and distribution requirements, (2) conformity with design documents, codes and standards, (3) quantity and dimension (4) scope and coordination.

Students in a concrete construction course are introduced to these concepts and expectations, and are required to review specifications and drawings and extract the contractual information related to concrete. They must record all details related to the concrete on the project including, but not limited to, the submittal process, testing procedures, mix requirements, finishing methods. With that information, students develop excel spreadsheets listing these items and then having a detail log for each item. The series of excel spreadsheets are hyperlinked together, allowing easy access and upload of the information.

Starting with the parametric 3D CAD software such as Autodesk Revit, the student creates a schedule of values for the concrete work on the project. This is tabular summary lists parametric information about the concrete system, as labeled above (3) quantity and dimension, showing information such as the room number, the area of the room, the perimeter, the thickness of the concrete, and all other information entered by the design professionals. The students are directed to develop a series of spreadsheets that would tie to this initial spreadsheet and would capture information related to (1) submission and distribution requirements, (2) conformity with codes and standards, and (4) scope and coordination.

This exercise leads the students to develop a framework and methodology to approach daily construction tasks that are project independent. The content of the table is however a project dependent. The students are encouraged to think along the lines, of how can use technology and computer to make my work easier and more efficient. This effort can be, upon graduation, the starting point for the students to pursue and further develop these tables to capture the essence of their work and daily tasks and activities in the construction industry.

This information entered into the excel sheets capture lifecycle information and can be complemented by a series of logical analysis of data given, can have excel suggest placement methods, trigger thoughts about concrete finishing based on the size of the area and the type of the finish and the setting time due to different mix. Excel, based on previous historical data or simply data based on equipment and resources productivity can suggest machine finishers or the size of the crew to manually finish the concrete.

Students are thinking like a construction manager and not just calculating the mix design, or reciting information about concrete slump and design mix requirements, but applying the knowledge to a project and understanding the importance of that information for a plan of action. Applying knowledge to a real project, extracting information and coming up with strategies on materials to use, crews to be, and building decision making tools are all outcomes of this module.

Room #	Material	Area (SqFt)	Thickeness (in)	Perimeter (Ft)	Finishes	Concrete Type	Responsibility	Notes
B001	Concrete	400	10	80	Smooth finish Concrete	Type 1	Field personel 1	
B002	Concrete	600	10	100	Stained concrete finish	Type 2	Field personel 2	
B003	Concrete	900	12	120	Exposed concrete	Type 3	Field personel 1	
B004	Concrete	400	10	80	Carpet	Type 4	Field personel 2	
B005	Concrete	400	10	80	Vinyl cover	Type 5	Field personel 3	

Column1	Column2	Column3	Column4	Column5	Column6	Column7	Column8	Column9
Concrete type	Size of Aggregates (in)	Slump (in)	Density	Water/Cement ratio	Air/Entrained admixtures	Curing method	Submittal information	Design Mix

Column1	Column2	Column3	Column4	Column5	Column6	Column7	Column8	Column9
Submittal #	Description	Date initiated	Date submitted	Status	Date received	Decision		

Column1	Column2	Column3	Column4	Column5	Column6	Column7
Name	Title	Company name	Email	Phone number	Address	

Figure 1: Sample table for recording concrete specifications in BIM model

Once these tables are organized and linked together, we can then apply to the BIM model. In the Revit model, a hyperlink to the tables can be made so that anyone can click on the location and see the status of submittals, mix requirements, etc. The tables can also be updated in this area. This becomes an integral part of the project documentation. Although this is not a fully automated process, it is one way for students as future construction managers to leverage technology and become more efficient at doing their job. It helps the students stay focus on the big picture and not get lost in the technical details of concrete. They see that the size of aggregate, the density of the concrete and the amount of water in the concrete and how it effects the overall productivity of the project. By organizing the information in tabular data and they and they can formulate the rationale and their decision making is becoming automated. Figure 1 above represents a sample of the tables and the hyperlinks to capture the life cycle information related to the concrete system, as described above.

Concrete type shown in the extract form the first table is hyperlinked to the second table extract shown just below. By clicking on the content of the cell in concrete type, once is linked to the second sheet showing more relevant details about that particular concrete used. The content of the responsibility field is linked to the extract from the table personnel log and more information is accessed. The content of the notes fields are linked to the submittal log, and allow access to the various information related to the submittal process.

3.2 Mechanical, Electrical, Plumbing (MEP) Module

The most common use of building information modeling / management (BIM) in the current construction industry practices is in the mechanical, electrical, and plumbing (MEP) systems of a building. These systems make up as much as 50% of the project value and represent the major challenges when it comes to project coordination, overhead coordination, and clash resolutions. Construction managers (CM) face various challenges throughout the stages of the project. The assignment was given as a group project. A lecture was given to the students with an example of how a MEP component can be integrated into a BIM model. The lecture explained how the students can connect equipment over the Preconstruction, Construction, and Post construction phase by storing information in the model. Table 1 is an example of the lecture information which was provided to the students.

Table 1 Matrix for Boiler in MEP model

	Preconst. Phase	Const. Phase	Post Const. Phase
Specifications	X		
Manufacturer	X		
Codes	X		
Storage	X		
Weight	X	X	
Size	X	X	
Delivery Method	X	X	
Installation	X	X	
Safety		X	X
Wiring Diagrams		X	X
Operating Voltage		X	X
Operating Amps		X	X
Maintenance			X
Adjustments			X
Shut Down Procedures			X
Warranty			X

At the preconstruction stage, the CM major challenge is the visualization of the MEP components in order to schedule workflow and develop accurate quantity take-off. At the construction phase, the CM major task is jobsite coordination and quality control. During the post-construction stage, CM is responsible for commissioning, maintenance, and warranty work related to the MEP systems. The students approached BIM from both the modeling and management perspectives. The 3D BIM model helped the students visualize the MEP systems and their components as they relate and fit into the building, as well as the relationship to the other building systems. On another level, the students took a CM approach to collect the information needed to carry on the work throughout the various phases of the project. Findings from this exercise proved very helpful to engrave the student's learning and understanding of the MEP systems, therefore serving as a great methodology to complete the objectives of this class. In addition, the students developed a plan to manage and share MEP information from a life cycle point of view.

During the lecture, the students were assigned to groups by the instructor. The groups were made up of a cross experience with each group including students with a high level of MEP experience partnered with students will less experience. The teaching style used is a natural peer teaching as the students' research an equipment example. The objectives for the assignment include:

1. Identify a construction component of your choice in the MEP area

2. Analyze what kind of information is needed to successfully complete the construction of this component (information pertinent to code, site supervision, site coordination, long lead item, description, delivery logistics, etc.)

3. Categorize this information by pre-construction phase, construction phase, and post-construction (maintenance and de-commissioning).

4. Develop a schematic approach demonstrating how to link and manage this information from a life cycle approach point of view.

Utilizing Learning Systems Blackboard Course Management software, an assignment drop box was set up for the students to post their work. They were given one week, including a 2 hour lab period, to research and develop the assignment. The deliverables which were required included:

1. A presentation including visual aids (Power Point or other presenting aid), that will be a minimum of 5 minutes and a maximum of 10 minutes.

2. All group members must be a part of the presentation

3. It should include a graphical representation of the component

4. All information from listed in the objectives should be included

5. The visual should show the schematic approach. How would you track this information and document using BIM?

Samples of the student schematic layouts are shown in Figures 2 and 3.

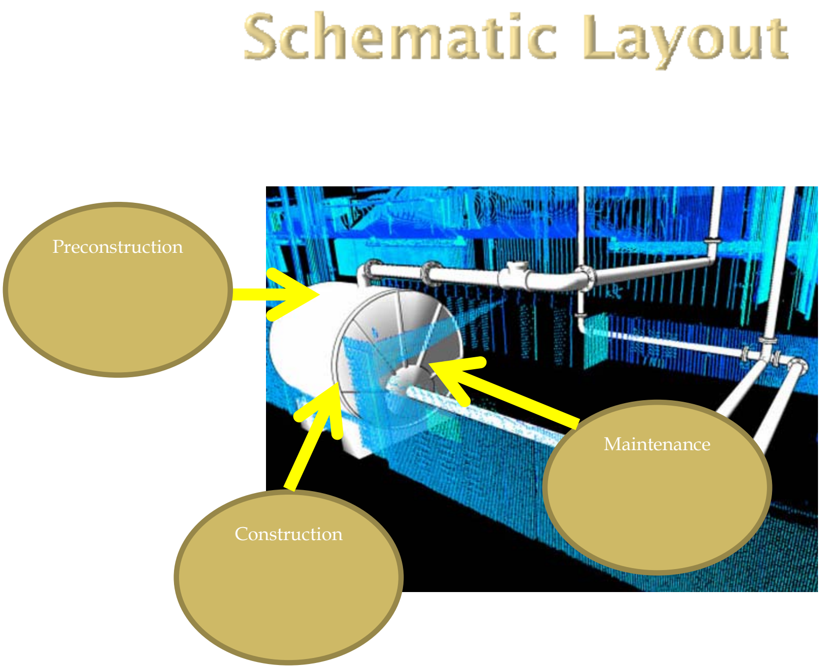

Figure 2: Schematic layout and visual of Boiler

Figure 2 is very basic approach to visually showing that a manufactures 3 D model of equipment can be used to connect the database of information for each phase of a project. Figure 3, demonstrates a broader understanding of the capacity of information that BIM can manage during the life cycle of MEP equipment

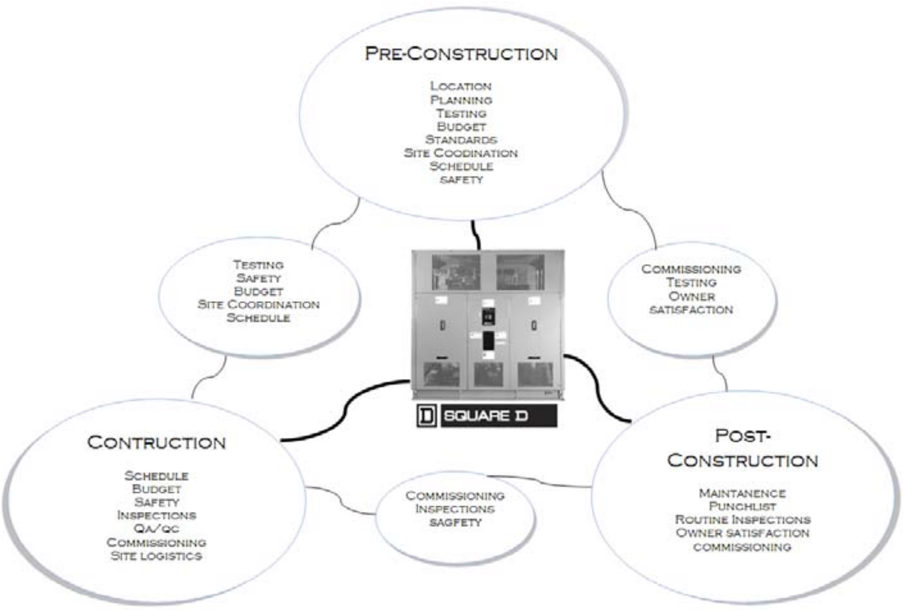

Figure 2: Schematic model of dry type transformer

4. Conclusions

The presentations of the students' MEP and concrete BIM assignments demonstrated that the students could connect data (information) to BIM 3D model. This generation of student has been exposed to new technology every year. They are very accepting of technology and value the power of computer graphics. The first year of integration of the upper level course assignments, the students did not have the software knowledge to produce the BIM module. The exercise was a demonstration of the power of the technical information and documentation that could be utilized on a construction project. Over the next 3 years, this assignment will grow from not only theorizing about the data, but a project will be developed to expose the students to the collection of data and manipulate a BIM model. The introductory assignment was first delivered in Fall 2011 and 3D models were produced. The challenges of implementing BIM into a curriculum is the level at which students should be proficient in the manipulation of the BIM model. What is the expertise of the MEP project managers of the future? How much time should be spent in this curriculum on software training versus model manipulation? These are all questions and concerns which will be answered as trial and error of assignments and the input from industry towards the implementation of BIM.

The three main goals of the mission statement for this department are:

- Provide the educational opportunities that prepare students to become professional constructors/managers of the construction process

- Engage in scholarly activities that keep the Department at the *State of the Art of Application*

- Provide service and outreach activities to the construction profession (www.xxxx.edu)

Weaving the BIM model and documentation management exercises within the curricula exposes the students to multiple levels of applying technical knowledge and building tools. It aligns with the mission for the department and the needs of the industry partners. As students increase their level of experience, they can fine tune the tools developed and take them to jobsites to use as they work. The final step for this process would be to develop a capstone course which integrates the building, facilitating, and managing of the construction documentation through the building of a BIM model. The next steps are to integrate schedule and cost modules into the curriculum.

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Use of Building Information Modelling in responding to Low Carbon Construction Innovations: An Irish Perspective

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At present the Irish construction industry is facing one of its most uncertain and challenging periods and will see major cuts in all areas of the economy in 2012. Despite this, Ireland pushes forward in sustainability initiatives with the Government ruling that environmentally-friendly policies are to get priority in competing for State contracts worth up to €16 billion a year. This and further initiatives are in place, so as to reduce greenhouse gas emissions by up to 20% by the year 2020.By the end of 2018 the public sector must own or rent only buildings with high energy-saving standards and promote the conversion of existing buildings to "nearly zero" standards. Furthermore, the "retro-fitting" of Ireland's existing building stock will challenge Ireland to meet carbon targets. This paper outlines how Building Information Modelling (BIM) can be utilised on future and present public works projects in Ireland to significantly assist the Irish Government in managing a low carbon energy future. The paper will focus on the application of a sophisticated BIM model in helping to predict the performance of buildings or assess retrofit/upgrade options in managing low carbon construction. The authors' data collation methodology involved the testing and analysis of a BIM model for a public works project, used during a four day workshop in late 2011. The workshop proved a success and provided the platform for the Irish Government to see first-hand, how a collaborative BIM model used on public works projects could provide a low carbon future for both future and existing building stock.

Keywords: Building Information Modelling, Low Carbon Construction, Public Works Projects, Sustainability

1. Introduction

At present the Irish construction industry is facing one of its most uncertain and challenging periods and will see major cuts in all areas of the economy this year. The Irish construction industry has experienced a severe contraction in construction output since it peaked in 2007 at €38.4 billion, to a return to output volumes of around €10.5 billion by the end of 2011 (DKM, 2011). Despite this Ireland pushes forward in sustainability initiatives with the Government ruling that environmentally-friendly policies are to get priority in competing for State contracts worth up to €16 billion a year (Gormley, 2010). The Government have also announced details in 2012 of a €1.5 billion programme to provide new schools and extend existing schools across the country. These initiatives are to be complemented by the Capital Works Management Framework (CWMF) which was introduced by the Department of Finance (2007). The CWMF is a series of documents which collectively describe the operating environment, procedures and processes to be followed for the delivery of capital works projects. The aim of the CWMF is to ensure that there is an integrated methodology and a consistent approach to the planning, management and delivery of public capital works projects, with the objectives of greater cost certainty, better value for money and more efficient project delivery. Within the CWMF the Irish government published a new suite of public sector contracts. In addition to this there is a plan to bring Ireland in line with the Energy Performance of Buildings Directive (EPBD). The EPBD will ensure that Ireland meets strict EU regulations set by the European Parliament since 19th May 2010 and avoid crippling fines which could prove detrimental to an already faltering economy. This directive requires that:

- All buildings built after 31 December 2020 must have high energy-saving standards and be powered to a large extent by renewable energy.
- By the end of 2018 the public sector must own or rent only buildings with high energy-saving standards and promote the conversion of existing buildings to "nearly zero" standards.

In order to successfully compete within the public works sector and guarantee that Ireland meets its carbon target deadlines, it is recommended by the authors that the Irish Government move towards the mandatory imposition of Building Information Modelling (BIM) on public works projects by following a similar methodology to that adopted in the UK and other countries.The Irish public sector must consider a strategy similar to the recent UK Low Carbon Construction Innovation and Growth Team Report (2010), in which it is recommended that companies in the wider construction industry undertake the following three-fold tasks:

- to de-carbonise their own business;
- to provide people with buildings that enable them to lead more energy efficient lives;
- to provide the infrastructure which enables the supply of clean energy and sustainable practices in other areas of the economy.

This process requires innovation and new ways of working and the acquisition of knowledge and skills that will provide competitive advantage at home and internationally. This innovative new way of working has come through the mandatory implementation of BIM. There is a plan in the UK for a phased five-year development that projects will be required to use BIM tools and techniques from 2016. This plan was devised around a hypothesis, which defined a scenario, in which the Government client would have an estate that was smarter and better equipped to face a low carbon economy, with associated reductions in delivery and carbon emissions.

2. Methodology

In an attempt to promote BIM within the Irish AEC / FM sector, a recent pilot project was launched by the Royal Institute of Architects in Ireland (RIAI) and the Construction Information Technology Alliance (CITA).This project involved a full professional team working in conjunction with the Department of Education and Science (DOES) on a generic primary school project. The main goals of the workshop where to:

- raise awareness and promote a higher level of understanding of BIM;
- demonstrate a more effective way for teams to collaborate;
- assess / demonstrate some of the BIM software tools available;
- validate designs through digital analysis;
- test BIM technologies in responding to low carbon construction demands.

This workshop served as the primary research tool for this paper and provided data with regard to testing the implementation of BIM on public works projects, as a method for adding cost certainty to contracts and managing low carbon construction. This paper will also review the use of BIM initiatives to procure public sector buildings and manage low carbon construction internationally and relate how those experiences can be applied to Ireland.

3. Background

The authors conducted a literature review of journal papers, professional publications and research articles with regard to low carbon construction and BIM. The literature review focused on the three main areas detailed below in order to present the perceived benefits of using BIM in responding to low carbon construction innovations in Ireland:

- Construction carbon footprint and BIM.
- Global implementation and barriers of BIM.
- BIM in managing low carbon construction in Ireland.

3.1 Construction Carbon Footprint and BIM

Hallberg and Tarnardi (2011) identified the construction sector as the largest industrial sector in EU-15. In addition they concluded that from an environmental point of view the construction sector is in a unique position as it is accountable for 46 % of the total energy usage, 46 % of the CO^2 emissions and generates 40 % of all man-made waste. Okoroh et al. (2012) estimated that approximately 80% of carbon emissions caused by buildings are created during the operating phase of existing buildings. This issue is even more concerning in that Ireland's neighbours in the UK, produce 50% of their total CO^2 emissions from energy used in heating, lighting, and cooling buildings, with an additional 25% of CO^2 emissions arising from the energy used in transporting people and goods during the construction and usage of these facilities (Pearce, 2008).

These figures have illustrated that the construction industry should move towards a more productive way of doing business in order to control escalating energy costs and produce more productive methods of managing low carbon construction. This can be achieved through the use of BIM, which can ensure a thorough life cycle analyses, service life planning and more solid life-cycle optimisations of the design and use of the buildings (Hallberg and Tarnardi, 2011). BIM is beginning to change the way one builds, the way the buildings look, the way they function and the way buildings are maintained and managed (Godager, 2011). Godager further explains that resource consumption and waste production together form a construction trigger for a number of environmental problems. BIM is seen to be a very important tool to handle all these challenges. It is generally reported that the level of analysis required to predict the performance of buildings or assess retrofit/upgrade options is not feasible without sophisticated BIM models or computational analysis tools. This relatively new technology has allowed a new paradigm within the AEC sector, which has the ability to promote and encourage each stakeholder within the project to play a more prominent role. BIM has helped develop the way designers and contractors consider the entire building process from the initial design brief, all the way through the construction documentation stage, into the actual construction management stage, and finally the Facilities Management stage (Dzambazova et al., 2009).

3.2 Global Implementation and Barriers of Building Information Modelling

The revolution of BIM across the global construction world continues to grow and must result in Ireland adopting a similar methodology or face being left behind and unable to compete in foreign markets. The strong growth of the green building market has seen a greater encouragement in the adoption of BIM in the design and construction Industry. Green BIM is an emerging concept which can enable highly sustainable outcomes through energy simulation and prefabrication (McGraw–Hill 2010a). In order to participate in this lucrative market, Ireland must follow the example of various countries including the USA, Finland, Norway, Denmark, UK, Germany, Singapore and Korea, who are all currently in the process of developing BIM guidelines.

VTT in Finland, Rambøll in Denmark and SINTEF in Norway are the major research organizations in BIM in these countries (Wong et al, 2010).The involvement of companies in BIM initiatives within Europe, facilitated by buildingSMART, is increasing with involvement estimated to vary between 20 and 40% of the number of companies implementing BIM (Wong et al, 2009). Outside of the USA and Europe, Singapore is one of the few countries in Asia who have implemented BIM in the public sector, with Hong Kong in the process of establishing BIM guidelines to help increase productivity and meet established high standards that include tight schedules and high land costs. In a report by McGraw Hill (2010b) it was outlined that nearly 60% of total respondents are currently frequent users and 74% of Western European BIM users report a positive perceived return on their overall investment in BIM. Perhaps most encouraging to the Irish Public Sector is the move of their immediate neighbors, the UK, towards the legal implementation of BIM. Ireland needs to adopt a similar hypothesis and begin to move towards the legal imposition of BIM, in order to enhance low carbon construction and promote a carbon neutral future.

In order for Ireland to create a similar frame work to the UK there are a number of obstacles to be addressed in the form of both legal and technical categories. Some of the barriers as stated by McAdam (2010) include defining a process of implementation and ensuring all participants will be working from the same software. The same author details a number of further barriers, which include the extent to which a BIM model could stand as a legal document, the risk of the designer incurring the cost and in the case of copy right where the legal line will be drawn. One of the most effective ways to deal with these risks is to have collaborative, integrated project delivery contracts in which the risks of using BIM are shared among the project participants along with the rewards (Azhar, 2011). At present the US has two BIM specific contracts developed, the Consensus DOCs 301 and AIA E202 in which both use standard contracts for which a BIM addendum has been developed. The US Consensus DOCs 301 and AIA E202, through slightly different, offer a starting place in the development of this contract. In examining the UK Framework it is concluded that in order to work at a Level 2 that little change is required to the fundamental building blocks of copyright law, contracts or insurance. This is encouraging to an Irish perspective, as our current contracting arrangements are not considerably different to the UK despite the current suite of Government Construction Contracts Committee (GCCC) forms of contacts not been designed to encourage risk allocation or collaboration.

3.3 BIM in Managing Low Carbon Construction in Ireland

The need to reduce CO^2 emissions and energy consumption from buildings has never been more immediate. Godager (2011) outlined that there are more and more environmental requirements because of growing environmental challenges and depleting energy resources. This ultimately means that there is a need for focusing on building materials and for performance classification in the energy field. The European Union and its Member States have a large number of on-going policy initiatives directly aimed at supporting sustainability of the built environment. There are current climate and energy strategies implemented globally to try to ensure that by 2020 renewable energy will represent 20% of energy production; a reduction of greenhouse gas emissions by 20% and the reduction of CO^2 emissions by 80-90% by 2050 (Zeiler et al, 2012). There is a growing consensus that one must reduce one's dependence on rapidly depleting, carbon intensive fossil fuels, which, amongst other things, will involve overhauling how buildings are designed, constructed and used (Kilip, 2010). To achieve this Kilip (2010) outlined that in Ireland a combination of everything from introducing innovative policies, to enforcement of building regulations, to adapting to more advanced construction methods and technologies must be undertaken. It is critical that Ireland's return to economic growth is not matched by a corresponding growth in energy demand, where Ireland's future economic successes are not undermined by deteriorating environmental patterns and unsustainable energy usage (Lewis, 2009). The managing of low carbon construction in Ireland can be achieved through an innovative policy by the Government to implement BIM. This will provide a unique access to a combination of energy analysis tools that complement the BIM process.

Energy profiling in the built environment involves an analysis of the actual or predicted energy performance of buildings and/or an analysis of the embodied energy within the materials and methods used to construct buildings (Crosbie et al., 2009). Energy profiling involves comparisons between actual or predicted energy use and some type of benchmark or model intended to indicate regulatory requirements, average energy consumption or best practice. In a report issued in November 2010 for low carbon emission which is heavily referenced by the UK Government's Construction Client Group BIM Working Party Strategy Paper, it was found that BIM has the greatest potential to transform the habits and, eventually, the structure of the industry. With regard to house construction, Mah et al. (2010) outline how the BIM approach allows for rapid computations of CO^2 emissions from various house sizes, designs and materials. The use of BIM and the integration of an intelligent database permit end-users to calculate CO^2 emissions for different styles of houses with different types of construction methodology. The McGraw – Hill Green BIM Report (2010) details that robust tools exist within BIM to help in reducing significant carbon emissions through performing analyses on energy performance, lighting and HVAC systems.

The European AEC/FM Sector is also researching the use of BIM for sustainability designing, with a section of this research being funded by the European Commission through the EU FP7 funded project entitled 'Intelligent Use of Buildings' Energy Information (IntUBE). This project is detailed by Crosbie et al. (2009) who describe it as a scheme created to increase life-cycle energy efficiency of buildings by integrating the latest developments in the ICT-field into Intelligent Building and Neighbourhood Management Systems. The authors warn that BIMs and energy simulation tools can also hinder each other and that up to 50 % of the project team's time can be dedicated to performing energy simulation.

Other opportunities to mitigate high CO^2 emissions within the construction process range from scheduling changes to newer construction practices, such as pre-fabrication (Mah et al., 2010). Typical wastage rates within the industry are as high as 10-15% (McGrath and Anderson, 2000). A study conducted by the National Audit Office (NAO) showed that highly prefabricated systems can reduce construction periods by 60% and require 75% fewer operatives on site, with consequential benefits for the client, contractor and the local community. BIM is in the unique position to play a major part in the reduction of waste and, therefore, CO^2 emissions through the fostering of better off-site fabrication techniques. Detailing BIM software, such as Tekla Structures, can output data from the BIM model directly to machines for fabrication, saving significant time on the construction of a project, as the steel structure of a building is known to have a heavy lead time to site (Gavin, 2008). The BIM model can also allow most elements of the building, such as precast concrete elements or sheet metal and ducting systems, to be fabricated from the BIM model off-site. This all leads onto, as outlined by Mah et al. (2010), the BIM model resulting in having a positive impact on the environment due to reductions of CO^2 emissions and material waste disposal to landfills.

Ireland also faces significant problems in the near future through the "retro-fitting" of Ireland's existing building stock to meet carbon targets. The McGraw–Hill Green BIM Report (2010) states that Green BIM practitioners find BIM to be particularly useful when it comes to green retro– fitting. Over 25% of the survey participants views BIM as highly applicable for use in green retrofits, with a further 49% believing it to be of medium applicability. The convergence of BIM and Green Building could prove to be the catalyst for ensuring the adoption of BIM within Ireland for long-term gains for clients.

In an attempt to promote BIM within the Irish AEC / FM sector and test its application in regards to low carbon management, a recent pilot project was launched. The purpose of this workshop was to showcase BIM to the relevant Government heads and provide valuable primary data towards the implementing of BIM on Public Works Projects

4. BIM Pilot Workshop

The RIAI/CITA BIM workshop was held over four days in late 2011 with a number of subsequent presentations given to industry leaders. This workshop was used by the authors to test the research topic for this paper by conducting a number of interviews and through the collection of data from the results of the four day pilot. Semi-structured open interviews where used as the main tool of analysis.

4.1 Pilot Overview

The observer for the BIM project was the Department of Education (DOES) and the official observer for the event was the Office of Public Works (OPW).The workshop involved the deconstruction of an existing primary school building and rebuilding it using BIM technologies as outlined in figure 1. This involved a whole project team working in collaboration to maxamise low carbon construction and sustainability potential, through the harnessing of BIM technologies.

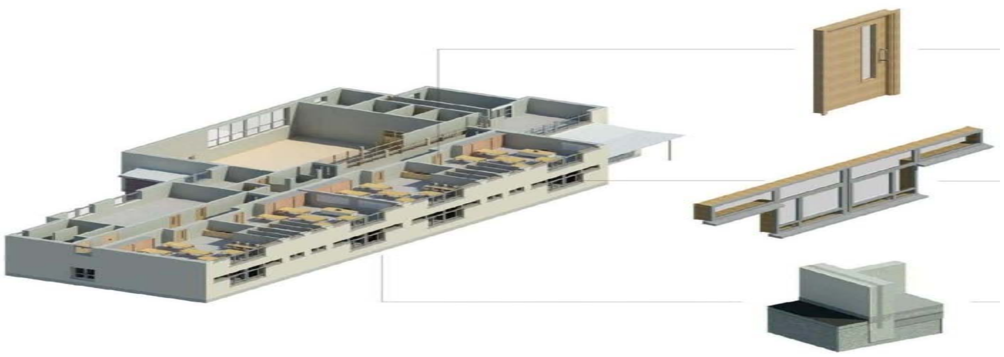
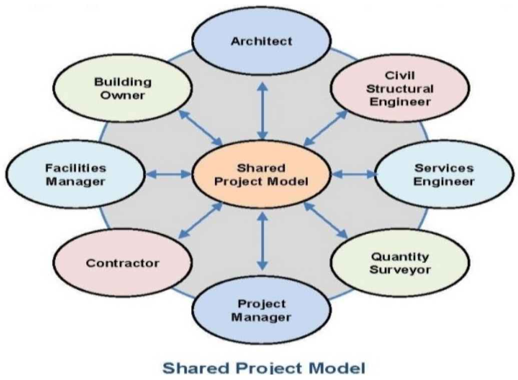


Figure 1 Workshop Overview

4.2 Pilot Team

The pilot team consisted of a number of leading design professionals from selected firms within the AEC/FM sector, integrated into the design team in order to foster the best method of collaboration, as illustrated in (figure 2). The pilot team was primarily made up of consulting engineers, services engineers, architects, and consultants as illustrated in figure 3. This team model also consisted of additional support from contractors, quantity surveyors, technical support, facilities management support for handover documentation and BIM energy specialists.



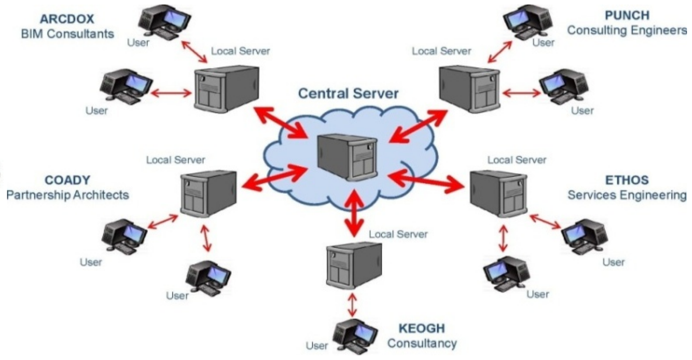


Figure 2: Shared Project Model *Figure 3: Pilot Team*

4.3 Pilot Activities

The BIM model was developed to respond to client specific requirements using a visual communication tool to meet their expectations. The design team was provided with a digital brief with the overall goal to design a BIM model of a standard generic DOES school. This model was exploded down to its components and then given to the design team to work on specific components. The various professionals involved all worked on their own model, which was synchronised with a central server, allowing all participants of the workshop to monitor each other's work and, therefore, promoting collaboration.

4.4 Pilot Feedback

The workshop derived results across all sectors and disciplines and strongly advocated the application of BIM to become mandatory in future Public Works Projects. The BIM model was effectively virtually built before having to be physically built, which allowed foresight on a number of key areas and helped identify eventualities that may occur on site. The BIM process added a greater cost certainty and reduced a significant amount of the design risk associated with contractor's cost. Through the collaborative process of everyone working on the same model, the design team was able to see what the other disciplines where doing and this fostered a greater team ethic throughout the design process. This resulted in a strong group dynamic, which in turned enabled the design team to identify areas of possible clash detection, as there was no legal restrictions or copyright concerns within the pilot. This further resulted in each profession learning from each other and addressing possible collaboration problems and concerns, which may present themselves in future live projects between the concerned professions.

Energy efficiency, according to one of the workshop participants, is not normally a priority at the design stage and decisions on materials selection, amongst other things, are purely driven on cost. The BIM process permitted a different and more sustainable method of construction to be undertaken which helped designers concentrate on energy efficiency and improved carbon construction. The BIM workshop allowed the designers to create four mass models at different orientations and to perform exercises in concept energy analysis, so as to choose the most economical and sustainable building possible. The energy model was inputted with weather predictions to aid in orientation data, internal floor areas, the number of people who will use the structure, cost of electricity and fuel, average lighting power, exterior wall area, window area, etc. to enable an accurate analysis to be performed. The energy analysis armed with this data was used to calculate the energy usage for the year and so, therefore, assuming discounts rates, a life-cycle energy usage / cost could be generated. The analysis also provided the user with the predicted renewable energy potential that could be harnessed from the roof PV potential (solar electric) and the wind turbine potential for the mass model, based on its climate and geometry. These figures were subsequently used to generate the net annual CO^2 emissions, which is basically the CO^2 emissions from electricity and fuel consumption for the analysed model, minus the renewable energy potential. This in turn permitted the BIM energy specialist to provide the architect with the information to suggest the most carbon-friendly building to the client. The results from this energy analysis are illustrated in figure 4 – 7, where mass model 4 shows the least carbon emissions on a yearly basis.

The analysed energy simulations for the different mass models enabled the architect to see what design changes best impacted the carbon output of the model. These changes, if the architect felt were beneficial to the overall lifecycle of the model, could be incorporated into the design. In the workshop the form and orientation chosen for the school was not the best performance-wise. The reason for this was that the information gained from the analysis allowed the design team to understand that there were minimal energy performance gains to be achieved by opting for a form that was more energy efficient, but performed less well, as a space for the occupants for their required usage. BIM allows an excellent opportunity to perform this sort of energy analysis which can be done quickly and should be used at each stage of design. The energy analysis can also be done when deciding on room and glazing layouts along with daylight analysis. The DOES have a set natural lighting guidelines for each classroom. BIM enables designers to pick windows that will be in line with Department Education’s standards and give the best lighting design. This exercise was carried out in the BIM workshop to inform window sizes based on the required daylight factor for each classroom. The designs from the model were also imported into Studio Max which enabled the surface of the road to be created virtually. This also allowed traffic to be seen through animation and could help predict traffic flow and, therefore, manage future carbon emissions through better traffic management and design.

The use of BIM enabled the designer to have the option to choose a carbon friendly design for the primary school. The energy analysis enabled a relatively easy calculation to be performed with regard to whole-life energy usage for all four design iterations. Energy efficiency lies at the heart of improved carbon management and the designers then have this information early in the design process, which can only have a positive impact on the building’s carbon footprint. To really investigate the carbon footprint then the embodied energy of all the building materials must be carefully examined.

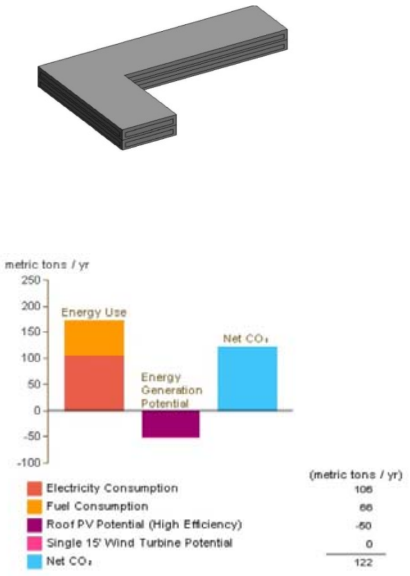


Figure 4: Mass Model 1

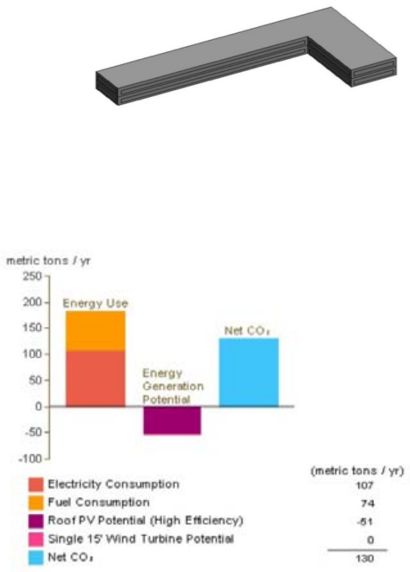


Figure 5: Mass Model 2

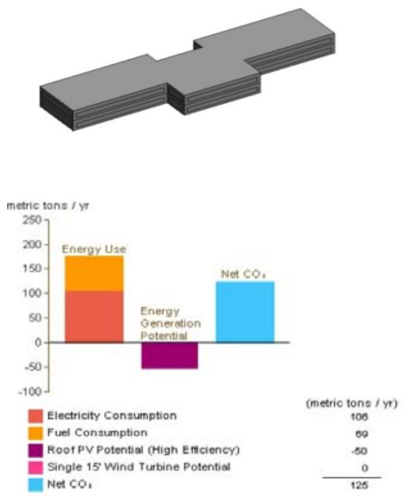


Figure 6: Mass Model 3

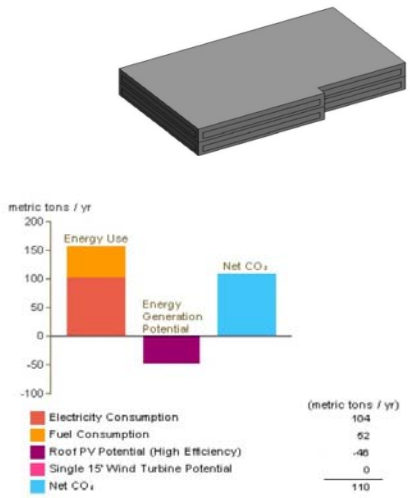


Figure 7: Mass Model 4

5. Conclusions

The lack of compatible systems, standards and protocols, and the differing requirements of clients and lead designers, has inhibited widespread adoption of technology on public sector projects in Ireland. These technologies have the capacity to ensure that all team members are working from the same data and that the implications of alternative design proposals can be evaluated with comparative ease. The

UK government’s move to demand by 2016 that projects are modelled in 3D Technology will lead to the elimination of coordination errors and subsequent expensive changes, which was at the foundation of historical public sector project delivery problems in the past.

The CITA BIM workshop has offered the opportunity for a whole design team to break a constructed primary school down to its core elements, and re-build it using a BIM platform, which would focus on best construction practice in regards to its overall life cycle. The BIM Model allowed a data rich model, allowing testing of design solutions to provide a more responsive building design to the client brief, and better coordination of all project information. The workshop proved a success and provided the platform for the Irish Government to see, first-hand, how a collaborative BIM model used on a public works projects could provide the cost certainty and achieve CO^2 emissions targets they so urgently seek. This model showed how, through a relatively simple energy analysis undertaken at the beginning of the project, the designer is permitted to view the life-cycle costs of that structure. This analysis can only have a positive impact on the building’s carbon footprint and help the client and his design team choose the most beneficial carbon based construction solution. The embodied energy of all the building material must be carefully examined, which will then along with further energy analyses provide the financial and environmental tools for the client to choose their building.

There is a need for a more innovative approach in regards to better carbon construction within Ireland, so as to ensure crippling fines are not enforced and carbon targets are met. Despite the success of the workshop, Ireland is still a long way from embracing BIM on public works projects. Representatives of the OPW noted that despite the benefits that BIM would have on a number of Departments within the Government, it would still require “an act of faith” for the Irish Government to fully embrace it. There is a notable lack of incentive from the Government and reluctance to incorporate more change, due to the recent introduction of the GCCC forms of contract. This fact, coupled with the fear of legal implications, such as, who owns the BIM model and which profession will carry most liability for the model, have left the Irish AEC/FM sector in an uncertain stance towards the implementation of BIM on public works.

The next step in the process of promoting BIM includes a suite of BIM workshops in 2012. These workshops will be primarily hosted by CITA and are to be sponsored by leading professional institutes throughout Ireland, so as to promote BIM within the Irish AEC/FM industry. These workshops will address a number of key areas, such as contractual implications, development of a BIM Library, process change management, the up skilling of existing workforce and technical standards that are all required for BIM implementation. These further workshops will serve as the focus for the central role that BIM can play in ensuring the practice of design, construction and facilities management for a long-term sustainable solution for the build environment.

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- Keogh Consultancy   Stewart Construction   Moore DFM
- Datech   Diatec

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The Rocky Road to BIM Adoption: quantity surveyors perspectives

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Abstract

Quantity take-off has remained the base activity performed for many of the services provided by quantity surveyors. Although many quantity surveying (QS) firms have moved from paper-based quantity take-off to computer screen take-off, quantification process still remains a time consuming process. Part of this tedious task also involves collating and clarifying information from different design consultants, all of which lead to non-productive and inefficient work. Automation of quantities and an integrated information exchange achievable through Building Information Model (hereafter referred as BIM) should enhance the services provided by QS firms. It is not clear how well quantity surveyors are increasing BIM adoption and getting ready for participation in BIM in their professional practice. The research reported in this paper was aimed at understanding the BIM experience of QS firms in Australia. Data collection was a web-based survey of 177 QS firms. Findings of this study shows that BIM is not readily adopted by QS firms due to the incompleteness of information in models, lack of knowledge about new business processes to drive BIM and cost of implementation. It appears that QS firms mostly participate in BIM in the form of computer aided take-off (with 3D drawings – non parametric modelling) in the project's front end tasks such as cost planning and bill of quantities and in the form of one way communication rather than in parametric modelling, quantity automation, collaboration and integration. There seems to be lack of clarity about the 'Time saving' benefits of BIM because QS spent more time cheeking the accuracy of model. The implications of the findings for technology adoption in construction and especially BIM adoption by QS firms are discussed. Ways of driving adoption of BIM-based working in the construction industry and especially by the QS are also highlighted.

Keywords: adoption, BIM, estimating, quantity take-off, quantity surveying, professional services

1. Introduction

The term “BIM” may be used to refer to the collaborative project delivery process involved in creating and communicating project information into a model by the design team. Thus BIM may be described as a collaborative mechanism (process perspective). From a process perspective, Autodesk (2011) defines Building Information Modelling (BIM) as “an intelligent model-based process that provides insight for creating and managing building and infrastructure projects faster, more economically, and with less environmental impact.” It facilitates simultaneous work by multiple design disciplines. Sometimes BIM is also used to refer to the product that facilitates collaboration in the project delivery process i.e the BIM itself (as a product). From product perspective, a BIM is a digital model of a building in which information about a project is stored. All information related to the physical and functional characteristic of the building are stored in the ‘smart’ objects (Scuderi, 2007).

BIM provides a platform for integrated information exchange through a single model. It reduces design errors and omissions with significant reduction in design time. In addition to its use as visualisation tool of spatial representation of the building components, data enriched model provides extraction of information of each element embedded in it (McCuen, 2009). Depending on the data in the model, it can either be 3D graphical model, 4D time model or 5D cost model and with further information stored it can be modelled to nD. Thus BIM adoption can be at different levels as highlighted by Australian Institute of Architects (2010). In fact in terms of progress towards BIM adoption, firms may be at different levels namely manual 2D, computer aided 2D, 3D drawings (non parametric model), intelligent 3D (parametric model), collaboration which involves sharing of object-based models between two or more disciplines, and integration which involves integration of several multi-disciplinary models using model servers of other network based technologies (the highest level of BIM adoption).

Because of its capabilities BIM-based estimating could transform and revolutionise the way quantity surveyors (QS) work. This study sought to investigate progress towards adoption of BIM by QS in Australia. Drawing from At breakfast seminar titled “Integrated Design and Delivery Solutions: Design Management in an Online Collaborative environment” organized by the Chartered Institute of Building Australia (CIOB) Australia branch at the school of property, construction and project management RMIT University on 21st March 2011, participants’ discussion suggested that quantity surveyors in Australia are somewhat not ready and are very reluctant to participate and adopt BIM. A similar anecdotal evidence of slow or lack of participation of QS in BIM was expressed by some participants at the NATSPEC Implementing BIM seminar on Wednesday 9th of May 2012 in Melbourne, Australia. RICS reported a similar finding in the UK (Building Cost Information Service, 2011). London et al (2008) also suggest that overall BIM adoption is slow in Australia. Thus the research reported in this paper is very important because it investigates the BIM experience of quantity surveying firms in Australia with a view to making recommendations that could facilitate widespread adoption of BIM-based quantity surveying services as well as BIM in general.

2. Quantity Surveying: The Evolved Profession and the Pivotal Role of Quantification

The history of quantity surveying profession should provide a useful context for understanding the development in quantity practice in Australia and elsewhere. It may also provide some useful insight into the widespread adoption or otherwise of new technology by the profession. Broadly speaking, the first reference to quantity surveying activities is found in the Bible (the holy book of the Christians) in the book of Luke 14:28 where the central figure of the Christian faith, Jesus, said: '*For which one of you, when he wants to build a tower, does not first sit down and calculate the cost to see if he has enough to complete it*? Thus it would appear that the traditional quantity surveying activities dated back to over 2000 years ago. However, the need for an organised form of quantity surveying emerged during the restoration of London after the Great Fire in 1666 (Winch, 2010:37). Quantity Surveyors who were in early days referred to as 'measurer' or 'surveyor', worked for contractors to measure for payment purposes only (Association of South African Quantity Surveyors, 2011). Later years saw the need for accurate estimates widening the role of quantity surveyors and as years passed by, it was considered economical for the owner to have a cost advisor to represent him rather than each builder preparing his own bill of quantities (Drogemuller and Tucker, 2003). According to AIQS's cost management manual (2006), 'Specified Bill of Quantities' are a single integrated statement of the description and quantity of all work and contractual obligations in the one document.' The preparation of bills of quantities as a basis for estimating the cost of works from design drawings and specifications seems to have become established at the beginning of the nineteenth century. While many countries, like Europe and America for a long time did the measurement role through architects, the profession became more popular in England and Scotland (Sanders, 2008). In Australia, the first recorded quantity surveying activity occurs in June 1819 at Hobart Town where a first quantity surveyor was employed to measure in 'standard measurement' the walls of a new county (Leach, 2008). The first quantity surveying firm was in 1853 and the first bill of quantities was prepared by an Architect in 1859. Problems of over/under measurement, material cost and increase in cost of labour in 1800's, particularly after the Great Depression of the 1920's and 1930's led to a call of professionals specialised in the measurement of building quantities (Sanders, 2008). Overtime this profession has had its rise and fall in demand but due to its role played throughout the project lifecycle, it has now attained an importance among the core players in the Australian construction industry as with United Kingdom and other commonwealth countries. In 1971 (41 years ago), a professional body association named 'Australian Institute of Quantity Surveyors' (AIQS) was formed in Australia to represent quantity surveying professionals.

Although the role of a quantity surveyor which was just confined to doing measurements for the sole purpose of making payments in 1600's, the role has changed over time. Quantity surveyors now provide cost plans and prepare bill of quantities, which are now considered as the traditional services of a quantity surveying firm even now. According to a survey in UK in 1998, cost planning and advice services were seen as a leading QS service with potential to growth (Burnside and Westcott, 1999). In Australia, the traditional core services provided by the firms are Estimation, Bills of Quantity (BOQ) and Builders Quantities (BUQ), Contract Administration and specification whereas some firms extend their service to provide non-traditional services such as Facility Management, Expert Witness, Due Diligence reports and many others (Smith, 2010). To accommodate these new roles, the skills required by quantity surveyors have now extended from just measurement to the ability to read drawings, have knowledge of construction materials and technology, the ability to visualise fitting of components from drawings, the knowledge of occupational health and safety issues, knowledge of relevant legislation and many others (Hodgson et al., 2008). Since quantity surveyors derive income from the construction industry, any changes occurring in the industry will greatly affect the way the profession operates (Frei, 2010). The changes occurring in the construction industry with an emphasis to shift from 'cost' to 'value' and importance of the procurement and management skills has changed the role of current day industry practitioners (Poon et al., 2000). Thus quantity surveying firms have now extended their roles to include many services into their firms to gain a competitive edge. With the declining use of bill of quantities driven by the change in procurement strategies and the higher cost involved in producing a bill of quantity, some quantity surveying firms started to include their services to provide builders quantities for the contractors in their portfolio (Drogemuller and Tucker, 2003). Quantity surveyors are currently considered as Cost Managers or Construction Economists who is one of a team of professional advisers to the construction industry by estimating and monitoring construction costs, from the feasibility stage of a project through to completion (Australian Institute of Quantity Surveyors, 2011). They are also involved after construction in preparing tax depreciation schedules, replacement cost estimation for insurance purposes and, if necessary, mediation and arbitration. With their increasing role in providing advisory services, project management, cost and value management [including life cycle costing analysis], it is apt to call 'quantity surveying' as 'project cost management' (Poon et al., 2000). With the unique and challenging nature of each construction projects, the current role of the quantity surveyor has become more strategic due to the proactive role in the management of costs in all phases of the project rather than just providing cost information for design proposals (Burnside and Westcott, 1999). Quantity surveyors are now well placed in the industry and regarded as major information handlers on construction projects as the majority of information flow has cost implications (Best et al., 1996).

With external factors playing a part in the roles performed by quantity surveyors, recent impact of the global financial crisis (GFC) has highlighted the need for quantity surveyors to pursue diversification of services and sectors. Leading edge QS firms which offered diversified services have withstood the impact of the crisis during the downturn times (Frei, 2010). With clients seeking value for money and collaborative relationships, there is a need for the profession to provide services with broader engagement, specialist insight and focus on value by adapting to innovative technology and to new socio cultural, political, legal and environmental exposures (Frei, 2010). While the role of quantity surveying professionals has changed over time, the quantity take-off (QTO) (also referred to as quantification) for the purpose of cost estimation and material ordering remains one of the core aspects of the quantity surveying practice. It still remains a basic skill leading to a competent quantity surveyor (AIQS, 2005; PAQS, 2001) and upon which whole life project financial management rests. Thus any technology that facilitates the quantification process has the potential to change and revolutionise the operation of the quantity surveying practice.

3. The Case for BIM-based Quantity Surveying Services

Traditionally, when estimating project cost, estimators do manual take-off or alternatively digitize architects paper drawing or import CAD drawings into a cost estimating software package to enable quantity takeoff. These methods are fraught with human errors and often lead to inaccuracies in estimates. Quantification errors may arise in the form of mistakes, arithmetic errors, processing errors, data extraction errors from drawings and data bases, and double or multiple counting (Olatunji, 2011). Inaccurate estimates have been identified as one of the major underlying sources of project failure in construction (Aibinu and Pasco, 2008). Many statistical/mathematical and intelligent models using historical data from completed projects have been developed to reduce inaccuracies in estimates (for example, Aibinu, *et al*. 2011). However, these mathematical models are inadequate due to the uniqueness of building. They are useful only at the early stage of projects development when the client is interested in indicative projects cost. With its computable information and single information-sharing model driven by a collaborative environment, theoretically BIM can offer many benefits to the quantity surveyor because of its quantity automation capabilities – important because when preparing cost estimates, quantity surveyors perhaps spend 50-80% of their time on quantity take-off (Autodesk, 2012). Other potential benefits include: help provide cost information consistent with the design, better visualization of design for costing purposes and overall time savings, to mention a few. Cost is one of the most important elements in a project development. Cost information is a feature of most of the role played by QS. Meanwhile, accurate cost estimating depends on accurate quantification. Thus technology (such as BIM) that potentially improves accuracy in quantification would impact cost estimating in a significant way and would impact all other services provided by the quantity surveyor and in turn would have positive implications for a project as a whole in terms of better outcome and value for money. Though BIM is said to have been in the industry for many years, the past few years have seen an increase in the use of BIM worldwide. While BIM is yet to be used in all construction projects worldwide, a study by McGraw Hill Construction in 2009 has indicated a significant increase in the use of BIM. A recent Australian study conducted in 2010 has indicated that use of BIM by the construction industry would provide potential economic benefits to the country and that it is being used by various industry players. However, it is not clear whether or not quantity surveyors find BIM a useful concept and whether they perceive a great benefit in the adoption of BIM-based quantity surveying services. It is also not clear what is the BIM experiences and perceptions of the quantity surveying profession in Australia and how much has BIM been adopted or how much are they ready for BIM adoption. Perception is important since culture, attitude and ultimately practice are driven by perceptions.

4. Australian Quantity Surveying Practice and Technology Adoption

In seeking to understand barriers to progress towards BIM or drivers of progress towards BIM, a brief overview of how Australia QS practice has been influenced by ICT in the past would be helpful. Australia has already made a significant contribution to the development and dissemination quantity surveying software. Estimator II was created in Melbourne in 1978 and was widely used by 500 clients across Australia, Southeast Asia and New Zealand. RIPAC software was sold in 1985. Development of Buildsoft software started in 1986 and has become popular across the industry with capabilities in the area of estimating, digitizer take off, palm pilot sight manager and progress claim, electronic tendering system, price guide to mention a few. ROSS software was developed by Rider Hunt in 1987 while CostX was released in 2003-2006 (Hemmett, 2008, in Sanders, 2008 page 324-333). In terms of widespread adoption of technology, according a survey (Smith, 2006) which studied the trends in the utilisation of automated quantities by the quantity surveying firms in Australia, non-user QS firms of electronic drawing, was reduced from 85% to 69% in 2005. This indicates that there are still QS firms which have not changed over to new technologies and still do the traditional quantification. Anecdotal evidence suggests that the advent of CAD has been received with mixed feelings. Some perceive CAD as a challenge to the QS profession and it could lead to the demise of the quantity surveyors (Sanders, 2008). Others offered a more optimistic view proposing that CAD as a tool that could offer QS a good opportunity at the early stage of design but if those opportunities are missed, and taken instead by other professions, there is the real danger that the growth of CAD will signal the demise of quantity surveying as distinct profession (Atkin, et al, 1987). There is no doubt the QS profession need to embrace the use CAD and or advanced way of working and tool such as BIM. They need to explore the opportunities inherent in BIM to deliver value in their areas of professional services. To make progress in this area, it would be useful to understand the BIM experiences and perceptions of quantity surveyors.

5. Research Method

This study investigates the BIM experience of quantity surveying firms in Australia and progress made by firms towards BIM adoption. A web survey was sent to 180 Quantity Surveying firms on the Australia Institute of Quantity Surveying business registry. 10 firms opted out of the survey and 3 email invitations bounced back. The effective surveys sent out are 177. Forty out of the 177 firms responded to the survey representing 23% response rate. 30% of the responses were received from New South Wales; 22.5% were from Queensland; 20% from Victoria while 12.5%, 7.5%, 5%, and 2.5% were from Western Australia, the Australian Capital Territory, South Australia and Tasmania respectively. The respondents are from diverse firm sizes, small, medium to large firms (35% employed 6-25 staff while 50% employed 0-5 staff, 5% employed 26 to 50 staff; 5% employed 51 to 100 staff and another 5% employed over 100 staff. Majority of the respondents were Partners or Company directors. 10% were Associate directors while 17% and 5% were Senior quantity surveyor and Quantity surveyor respectively. Also 45% of the firms have been in quantity surveying practice for more than 26 years while 47.5% have been in practice from between 6 to 25 years. Around 40% have annual turnover of over $10million. Of the 40 respondents, 75% of them have more than 15 years of experience. When put together, the data comes from firms with significant years of experience and respondents who are at top management level. Hence their responses can be confidently relied upon. Estimating and Cost planning is a core activity of the majority of the firms. 62.5% are involved in non-traditional services such as construction planning project management, dispute resolution and feasibilities studies. 5% are involved in the development of estimating software.

The survey was designed to capture quantitative and qualitative data. Drawing from an illustration by Mr Carl Agar – the BIM Director of Sterling Group, Melbourne Area, at the 'NATSPEC Implementing BIM' seminar on Wednesday 9th of May 2012 in Melbourne, Australia we believed that BIM train has left the station worldwide and so this study wanted to know from QS perspective whether they are on board the BIM train, and whether they have the right people (skills) on board, and whether they are on the right seat in the BIM train. Additionally, we seek to explore whether or not the BIM train is heading in the right direction in Australia. Thus the survey contains open-ended and closed ended questions. Questions were directed at issues relating to progress towards BIM adoption, impact on staff/skills of progress towards BIM, difficulties with BIM, benefits of progress towards BIM, challenges/drivers of progress towards BIM adoption.

6. Findings and Discussion

6.1 Progress towards BIM adoption

In order to identity the progress of firms towards BIM adoption, respondents were asked to provide information about the current method of quantification used in the preparation of cost plan/estimates, bill of quantities and other services. The results show that 35% of the firms use only electronic measurement, 50% use both manual and electronic measurement while 15% of the firms still do paper based manual takeoff. The results suggest that 85% of the firms engaged in some form electronic take off indicating that a large number of firms are making use of the technology to follow the market trend and to make their services efficient. The finding also suggests that as new technologies evolve, most of the firms follow the industry in order to remain competitive in the market. Even though 85% use electronic measurement, 50% of them still combine electronic measurement with the use of traditional paper based measurement. This indicates that technologies have not completely eliminated the traditional ways of working. The findings showed that the majority of the respondents work with 2D drawings (around 94%) for performing professional tasks. Only 22% work with 3D drawings while 20% have worked with intelligent 3D models (parametric models). None of them have experience working with 4D and 5D models. CostX estimating software is the most dominant software used (67%). Some use Buildsoft (23%). CostX is an Australia based software but now sold in over 40 countries including the UK, Ireland, USA, UAE, Malaysia, Singapore, Hong Kong, New Zealand and across Africa. Costx has a 3D quantity automation capability. Buildsoft is also Australian based software with 3D viewing capabilities for walls and openings. There are other softwares such as CATO CAD/BIM Measure (used by 17% of the respondents), On-screen take off (by OnCentre) (used by 11%). Another question ask the respondents to indicate their involvement with BIM-based projects. 37% of the respondents have been directly involved in a BIM-based project in Australia (hereinafter referred to as BIM users). 63% have not been involved in any (hereinafter referred to as non-BIM users). A respondent indicated that they have just been appointed to their first BIM-based project. 19% of the BIM users have been involved in the past 3-5years while 36% of the BIM users became involved in the past 2 years another 36% in the past 1 year. Hence it appears that QS involvement in BIM projects has increased in the past 2 years. Only few 9% have been involved for more than 5 years.

The BIM-users were asked to indicate the number of BIM-based projects they have been involved. 8 firms responded. Overall 42 BIM-based projects were listed by the BIM users. On the average there are about 5 BIM-based projects per BIM user. It should be noted that one BIM user accounted for 19 (around 45%) of the BIM projects. This implies that the frequency of involvement in BIM by the QS is very low and only occurs in the past 2 years. A RICS survey of QS members in UK and US show a similar result (BCIS, 2011). On the nature of BIM-based projects in which the respondents have involved, more projects are located in Queensland when compared to the other states. Most are institutional projects by government projects. The projects ranged from less than $10million to $500 million. Majority are based on traditional procurement (around 60%), followed by Design and Build (40%).The problem is that full benefit of BIM cannot be realised in a traditional procurement method because the traditional procurement does not support collaboration and integration of disciplines within the project development process. It is likely that on the projects listed by respondent as BIM based projects, BIM was only used as a tool to facilitate the technical tasks of individual participants rather than as a collaborative or integration tool. Thus the full benefit of BIM cannot be realised and so maturity and progress toward BIM adoption is expected to be slow.

The data shows that in about 66 projects BIM was created by the design consultants, but was not issued to the QS. Majority of the projects in which BIM was used for providing QS services are traditionally procured institutional projects by government in Queensland, Victoria and Northern Territory. This is followed by commercial projects by private clients. Again because of the dominance of traditional procurement it is likely that for most of the projects QS used the BIM as a tool only for the technical tasks i.e. facilitate visualisation during quantification, rather than as a full collaborative platform and integration. The data shows that measurement and quantification for cost estimating was done using 2D drawings. It is consistent with previous result which shows that many of the firm still use 2D drawings with onscreen take-off.

On the project where QS used BIM, the data shows that QS used the BIM mostly at the tender documentation stage followed by conceptual design, sketch design and detailed design stage. This is not surprising since QS used BIM in traditionally procured project where there is a limited opportunity for the use of BIM as a collaborative tool. BIM in such instances are only used to prepared tender estimate based on completed design and the advantage might be that it offers QS a good visualisation of the design thereby facilitating quantification and so cost estimating. Only one firm reported that they have used BIM from the concept stage to construction stage.

When asked how BIM was used for their services, majority stated that it was used predominantly for cost planning and for preparing Bill of Quantities. Two respondents indicated they have used BIM for contract administration. None mention facility management. Thus BIM involvement of QS is only limited to design stage and especially when design is completed. In one of the 6 case studies reported by CRC (Corporate Research Centres) in Australia, 4D BIM was used for checking the claims by the quantity surveyor by comparing with the base program of the model. Overall, it would appear that overall BIM has only been used as a tool for specific tasks of QS especially at the design stage rather than a collaborative platform or for team integration involving QS.

6.2 Impact of progress towards BIM

The effect of changeover process from traditional working to BIM-based working on staffs' attitude was investigated. Respondents were also asked to state the investment needed to adopt BIM-based working as well as difficulties encountered. The respondents' years of experience in BIM, total number of staff in the firm, staff skilled in BIM-based working, and the number of BIM projects in which respondents firm have been involved were also investigated. Seven respondents answer this question. The results show that firms who have been involved in more BIM projects have more staff skilled to work with BIM. This is not unexpected because firms BIM capability would increase as BIM-based project workload increases. 57% of the respondents reported that their staff were enthusiastic with BIM-based working while 15% stated that their staffs were resistant. 14% indicated that their staff showed mixed reaction - resistant and enthusiastic. 14% reported that their staff were very cautious in learning to work with BIM. It is likely that staff attitude would change over time as firms' BIM-based work load increases and staff get used to working with new software and a new way. Not all take-off and estimating software has the same level of BIM capability. Thus the respondents were asked to name the software implemented prior and during their involvement in BIM. The results show that 57% of the firm have been working with BIM compatible software for quantification using 2D OR 3D drawings before working on their first BIM-based projects. 87% of the respondents now use CostX after their first BIM-based project. To work with BIM additional investment is required only if firms current software are not compatible with BIM models. Being a new technology with many uncertainties and more capabilities to be explored by software providers, the cost of implementing BIM may grow over time because most of the software undergo frequently improvement with new capabilities and new versions released within few years. For example since 2003 Exactal have realised numerous versions of CostX estimating software. This is true of most software and most technologies. The challenge is that firm working with a version would need to upgrade when new version is released. Sometimes, projects documented in old version cannot be imported into new versions. Thus firm have to maintain the old version to enable them continue work on ongoing project already set up in the older version. Still yet firm may need to subscribe to the newer version if clients demands require the use of some of the capabilities in the new version. This brings added cost and uncertainties for firms.

On the question difficulties encountered when working with BIM, 'information included in BIM not enough to enable automation of QS tasks' was rated the most difficult issue followed 'scarcity of skilled employee who can work with BIM'. When information assigned to objects in BIM model is not sufficient, quantity surveyors will have to revert to onscreen or manual take-off. 'Employee disengagement' and 'Employee turnover' rated lowest. Respondents indicated some strategies they are using to address these difficulties. Firms who indicated that information in BIM is often not sufficient to enable quantity automation are working with design consultants to embed quantification data in the model. One respondent stated: '*discussing with consultants and requesting changes to know how they set up the model'*. Another respondent who has used BIM for quantification/estimation in 3 projects in the past 2 years stated that they reverted back to traditional measurement method as a result of this difficulty. Though employee disengagement was rated low as one of the difficulties encountered, one firm having difficulties with staff attitude and training stated: '*we engage more* *employees with flexibility to use new software. We work with architects and engineers to ensure quality data is embedded in the mod*el'.

6.3 Benefits of progress towards BIM

We investigated the experiences of respondents regarding the benefit of BIM for QS services. 6 respondents answered this question. Time savings (80%), visualisation (40%) and increased productivity (20%) were the benefits listed. However, one respondent stated that the time saved as a result of using BIM provides them with more time to analyse design options, reduction in intensive take-off, and ability to advise design team on areas of cost overspend. However, one other firm stated '*[BIM] will be quicker for take-off but not until the consultants get up to speed with drawing the model correctly*'. Another respondent stated that benefits are '*very little. BIM models are created with a different end goal to what QSs have. The information is not easily reconciled to QS measurement – in our experience*'. The benefits of BIM in a project cannot be realised by the quantity surveyors until the model issued to them are embedded with the required information needed for automating QS tasks. With insufficient and incorrect information, QSs may end up spending more time taking-off quantities manually. Another implication is that QS may spend more time checking the correctness and accuracy of the model and so the time savings may not be realised in the short run. This was expressed by one of respondents during the follow up interview.

6.4 Barriers to the adoption of BIM and Drivers

It is expected that BIM being a smart technology that facilitate collaboration and reduces complexity by providing better visualisation should be adopted widely by quantity surveyors to enhance their role in the project development process. However, findings from this study showed that there are certain barriers to the adoption of BIM by QSs.

Respondents in this study reported that in about 66 projects, BIM was created but was not made available to the quantity surveyors. It is possible that a project is BIM-based but the BIM may not applicable to QS services. Requirement for BIM-based QS services would depend on BIM brief for each project and would depend on the objective and the goals of BIM for the project. For example, some clients may request for BIM to facilitate post construction facility management purposes or operations rather than for containing cost within a limit. Thus clients demand can play a vital role in driving practices to make progress towards BIM. Low clients demand may also be as a result of uncertainties regarding BIM for certain tasks and in turn may be occasioned by a perceived lack of industry capability by clients. In that regards the role of public sector clients as facilitators of BIM adoption would be crucial.

BIM users were asked to state the initiator of BIM concept in BIM-based projects where they used BIM for QS professional services. The results show that in 40.6% of the projects BIM was initiated by the consultants, 25% - by client, and 25% by contractor and in 3 cases (9.4%) BIM was used for research. It appears that the clients demand for BIM-based services is generally low in Australia.

Consultants (engineers and architects) appear to be the parties driving BIM. This is consistent with historical development of the professions. BIM process is mostly driven by parametric models which is a core domain of the designers (Architects and Engineers). It is therefore not surprising that consultants are the dominant initiators of BIM. It has been said that the most effective way to make professionals embrace 3D design is through procurement contracts for projects (Teo and Cheng, 2011). While the activities of the public sector in some other countries are significant in driving BIM, the same cannot be said of the Australia public sector. Most of the BIM development in Australia has been driven by NATSPEC and BuildingSMART Australasia. There has been little support for driving BIM by Australian public agencies. Probably these agencies lack in-house capabilities to deal with digital files. Although the Built Environment Industry Innovation Council (BEIIC) set up by the Department of Industry, Innovation Science Research and Tertiary Education has produce a number of reports about the economic benefits of BIM and issues surrounding BIM there is been little or no concrete commitment and activities to realise some key outputs that could drive adoption of BIM i Australia when compared with other countries. One government agency taking the lead in BIM is the Queensland project Services. It is no surprise that the finding of this study shows majority of the projects in which BIM was used for providing QS services are traditionally procured institutional projects by government in Queensland.

We asked the users of BIM and the non-users to list the barriers and factors that would drive the use of BIM by QS. 27 respondents answer this question. The Reponses were analysed using content analysis. ‘Quality Information in Models’ was most frequently cited by respondents followed by ‘Case studies to demonstrate the benefits of BIM’, ‘Cost benefit analysis”, ‘Client’s requirement’, ‘Ease of use’, ‘industry wide use’. One respondent cited ‘Scenario training’. ‘Insufficient or lack of information’ by the design consultant is a common problem with the traditional take-off process (where QS measure from 2D or 3D drawings). Thus the cost of switching to BIM tool cannot be justified unless BIM overcome this problem. In fact during the follow-up interview one respondent stated that there is marginal time savings with BIM because they have to spend a significant proportion of the time checking the accuracy of the model prior to quantity automation.

Apparently, problems inherent in BIM can hinder its adoption. In fact one respondent stated that on one project they reverted to the traditional measurement and quantification because of the difficulties they encountered with the BIM. It is surprising that only 2 respondents cited ‘Integration with current software’ as a driver because one of the widely identified barriers to use of BIM is data interoperability of different software applications with BIM software. This is likely to be a reflection of the fact that non-BIM users accounted for 55% of the respondents. It is likely that non-users of BIM may not fully understand the ‘data interoperability’ challenges involved in BIM since they lack experience working with BIM. Also, this may reflect the level of experience of BIM users experience with BIM. Most of the BIM users have only used BIM as tool for front end project services such of cost planning and cost estimating at the design and tender documentation stage. Data interoperability becomes a more serious barrier when BIM is used as a collaboration tool as well as where firms have to use BIM for providing services such as financial analysis, contract administration, life cycle cost analysis and Facilities management. The problem is there are now many tools available for different tasks and processes in the project development process (design, construction, operation). In many cases, players use different tools for doing the same task. So, firms existing software may not be compatible with BIM software or with other players' applications thereby making it difficult to use the BIM as collaborative tool or to integrate disciplines. Also, data created in some applications may be digital but mat not be computable thereby constitute a barrier to the full adoption of BIM.

It appears that model progression specification – how to produce models that is useful for quantity estimating is a big issue that need to be addressed if QS must progress quickly toward BIM adoption. This is beyond the QS profession alone but the industry at large especially the designers. When respondent were asked to list barriers to adoption of BIM, cost of implementation was the most frequently cited, followed by incomplete model lack of knowledge, learning time, consultant attitude and change aversion. Cost items includes: software licensing and server capacity in relating to storage of data as QSs are not used to having such a high IT requirements. However, cost of implementing new software would depend on the firms existing IT facility. One respondent is concerned that where models are inaccurate the accuracy of estimate still remains the responsibility of the QS. This flags a legal issue that BIM need to address. One respondent states: *We have reviewed the BIM systems, but in our opinion it does not provide accuracy in measurement. Remember the quantities are only part of the BOQ, descriptions are more important than quantities. Quantity Surveying in the production of BOQs is about communicating in words what is on a two dimensional drawings into words that a sub-contractor can understand and price to reflect the scope of work. Computers cannot communicate the nuances of construction.*

A significant number of respondents stated 'lack of knowledge' of what needs to be done in the implementation/ change over from the traditional working to BIM working as a barrier to its adoption. Some are concern that the time needed to learn the new way of working, studying of projects in BIM would affect their business. Few respondents also claimed that design consultants are reluctant to share their model. Some cited aversion to change and the need for cultural change as well as resistance by older QS to new technology. Some of these barriers are consistent with previous studies.

Broadly speaking, it appears (or it may be deduced) that the barriers to the adoption of BIM by Australia QS are related to lack of demand by clients, contract/legal issues and uncertainties, information and communication issue about BIM, lack of standards and lack of information on need for business process changes and how to change those processes, skills transformation and adaptation issues, technology change and ability of firms to adapt to the change from cultural perspective and financial perspective. A review of BIM development in other countries suggests that the role of the public section agencies in driving adaption BIM is critical (Teo and Cheng, 2011). Based on national and government initiatives countries such as Singapore, Norway, US, and UK are now increasing the uptake of BIM. By 2016 it is a required that all UK government projects valued GBP5million and over must be procured with collaborative 3D BIM incorporating all projects and asset information, documentation and data transfer in electronic format. Similarly, in the US government agencies such as the US Department of Veteran affairs (VA) have been at the forefront of driving BIM. VA is committed to moving both the organisation and its services providers to BIM as effectively and efficiently as possible to integrating BIM process requirement and Integrated Project Delivery methodologies into its delivery requirements (VA BIM Vision). All projects (major construction and renovation) at over $10million are now required in BIM as design platform starting from 2009. VA have developed VA BIM guide and BIM object/element matrix manual which may be used for identifying and tracking BIM information during project. BIM element matrix depicts Building Information typologies/types. It attempts to standardise information necessary to include in BIM models at the creation and at various stages of development. In Singapore, the role of public sector client is also significant in driving BIM.

As far back as 1995, Singapore launched a strategic initiative - the Construction and Real Estate Network (CORENET), spearheaded by the Ministry of National development. The aim was to drive the construction industry through IT and especially BIM (Teo and Cheng, 2011). Through CORENET, e-plan check system was developed which is an automatic plan checking system for building permissions. The Singapore building and construction authority (BCA) implemented e-submission system as far back as 2001. It is an expert system that allows consultants to check their design for compliance with the regulation through the internet. It has been described as the largest projects ever undertaken by a government agency in support of BIM technology (Teo and Cheng, 2011). Singapore building and construction authority (BCA) has now set a goal to have BIM implemented into public construction by 2015. Also, Singapore has set up a centre for construction IT by the BCA as a means of educating industry in ICT research and development and help pioneering companies to kick-start the adoption of new technology and to build-up industry wide ICT adoption roadmap for the rest of companies (Centre for Construction IT, 2010). In Australia, the role of the public sector in driving BIM adoption is very minimal.

It is however important to note despite the little role being played by government agencies, in Australia there is now a National BIM guide developed by NATSPEC – a not-for-profit organisation owned by professional associations. The guide was adapted from US VA BIM guide. NATSPEC has also conducted study towards the development of construction information classification system for Australia as well as a series of seminar and workshop around the country. Despite the activities of NATSPEC, it is inconceivable how BIM adoption can increase and progress significantly across the industry without a more serious involvement of the public sector.

7. Conclusion

Automation of quantities and an integrated information exchange achievable through Building Information Model has the potential to enhance the services provided by QS firms. As a result of the potential for time savings, BIM with computable data should be readily adopted by QS firms. This study has investigated the progress towards BIM of QS firms in Australia. It appears that BIM is not readily adopted by QS firms due to the incompleteness of the model, lack of knowledge and cost of implementation. QS firms mostly use BIM in the form of computer aided take-off in the project’s front end tasks of cost planning and bill of quantities and cost estimating rather than in quantity automation , collaboration and as integration platform. If the quality of information embedded in BIM is not improved, QS would not benefit from the potential advantage that BIM can offer because QSs would need to spent time checking the accuracy of BIM. As a result time savings promised by BIM may not be realised. On top of that the information embedded in BIM need to be digital and computable and in the format that would make it useful for QS services. This can only be achieved if QS work closely with design consultants to define the information need to make BIM useful for QS tasks and services. BIM may be able to generate quantities however BIM tool at the moment cannot provide automated description of items. Can BIM tool communicate the nuances of construction to enable QS price a project? This is yet to be seen. Thus the ability of BIM tool to store digital and computable information is crucial to make QS realise the automation capacity of BIM. Some QSs still lack the knowledge of what business processes to implement and changes in order to switch from traditional working to BIM based working. Some are unsure whether or not the initial cost outlay to switch to BIM is justified. There is need for documented case studies to show how BIM can bring savings to QS work. There is also need for more awareness about BIM, cost and benefit, challenges, and how the challenges can be addressed. Some respondents have stated that they will use BIM if there is a requirement from client, whereas few have responded that the wide spread use of BIM by the industry which includes other consultants would drive the use by quantity surveyors. Finding ways of integrating BIM software with existing tools would reduce initial cost of change over as well as would increase adoption. Scenario based training can provide an actual hands on experience for the user with the ability to venture into the real project with confidence. On projects where BIM is required by the client quantity surveyors should not wait till the model is created but put effort on their side and liaise with the designs consultants early in the project to set their requirement in the model. Overall, there is need for a more serious involvement of the Australia public sector client if we must see a significant adoption of BIM across the industry ad by QS. It more likely that or firms would adapted quickly when BIM become a procurement requirement in government contracts and supported by government initiatives to help firms adapt to the change. Because of the various dimension involved, maturity and progress toward BIM adoption would also depend on coordinated effort of the various stakeholders across the industry.

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Usability and Impact of BIM on Early Estimation Practices: Cost Consultant's Perspective

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Abstract

Building Information Modelling (BIM) represents the formation of digital models for use during the planning, design, construction and operation stages of a facility's life. Whilst BIM is currently receiving high volumes of attention within the UK, it appears that general understanding of it is relatively low. The research has shown that BIM has the capacity to influence the way that the construction industry operates, with the focus of this study being to identify the usability of BIM for cost consultants, and it's likely impact during cost estimating. Research was carried out through an in-depth review of existing literature, to develop a conceptual framework, which was used to assess the potential advantages and challenges for cost consultants using BIM in their working practices. This research has the potential to help practitioners understand BIM in detail and how it can be embraced into current ways of working, as well as identifying potential areas for expansion of cost consultancy services, through BIM implementation.

Keywords: Building Information Modelling (BIM), Cost Consultant, Collaboration, Cost Estimating

1. Introduction

BIM is beginning to change the way buildings look, the way they function, and the ways in which they are designed and built (Eastman, et al., 2011). There is a wealth of research material available on the topic of BIM, providing details on how BIM can be used for purposes such as a modelling tool, information tool, communication tool and facilities management tool (Popov et al., 2006). For this research, Building Information Modelling is defined as the innovative production of a single building model, which works to integrate information supplied from all disciplines involved, for use by the whole project team (Succar, 2009). This is due to the fact that, for cost consultants, it is BIM's capability of combining graphical and data models, which will allow for the provision of more accurate cost information (McCuen, 2008a).

Building Information Models are digital representations of the physical and functional characteristics of a facility (National BIM Standard, 2011). The models intend to supply usable information throughout a projects lifecycle, by providing all details on the design, construction and operation of the building (BIS, 2011; GIM International, 2011). BIM also seeks to improve project collaboration and coordination within teams, as parties involved are able to add, share and view information in the same digital area (Autodesk, 2011).

2. Rationale

This paper was inspired by a current level of uncertainty as to how BIM will affect the cost consulting profession (Olatunji et al., 2009); these being consultants employed to act as client quantity surveyors, with primary roles of managing and controlling project costs (RICS, 2011b). It is important for cost consultants to fully understand how they can work effectively with BIM, as the UK 'Government Construction Strategy 2011' outlines that it will be mandatory for all public projects of £5 million and over, to be working collaboratively with 3D BIM by 2016 (Cabinet Office, 2011). Therefore, it is crucial that BIM is understood and embraced by this date, if companies wish to be considered for public projects.

With this in mind, this research aims to investigate the usability and impact of BIM implementation on cost consultants, with particular reference to the cost estimating stage. This was due to the fact that whilst recent studies have shown that 80% of quantity surveying firms are using elemental cost estimates in their working practices, the Royal Institution of Chartered Surveyors (RICS) reports a lack of BIM knowledge amongst its members (BCIS, 2011). Ku and Taiebot (2011, p.175) have found that BIM is "being rapidly embraced by the construction industry to reduce cost, time and enhance quality", with Eastman et al (2011) supporting this by explaining that clients are now realising benefits that BIM can offer them as owners. Therefore, it would appear essential that cost consultants increase their knowledge, awareness and usage of BIM, to ensure that they do not fall behind other construction professionals.

3. Methodology

A systematic literature review method was adopted for this paper in order to draw findings and form conclusions. Secondary information consists of sources of data that has been collected and recorded by others (Stewart and Kamins, 1993), which was derived for this research through a detailed literature review, to explore information already known on the topic of BIM (Robson, 2011). From this, tables were created to list the associated advantages and challenges for cost consultants using BIM, which was utilised to assess the usability and impact of BIM on cost consultants.

4. Literature Review

4.1 What is BIM?

BIM is a tool that can be used throughout the lifecycle of a facility by the whole project team (Azhar et al., 2007). This intends to improve collaboration between stakeholders (Grilo and Jardim-Goncalves, 2010) and encourage the quick and easy sharing of information, by bringing together the work of various disciplines, through a centralised model (Meadati, 2010). The resulting model is a three dimensional digital representation of a facility, which should allow for reliable decision making throughout its life time (National BIM Standard, 2011; Shen et al., 2012).

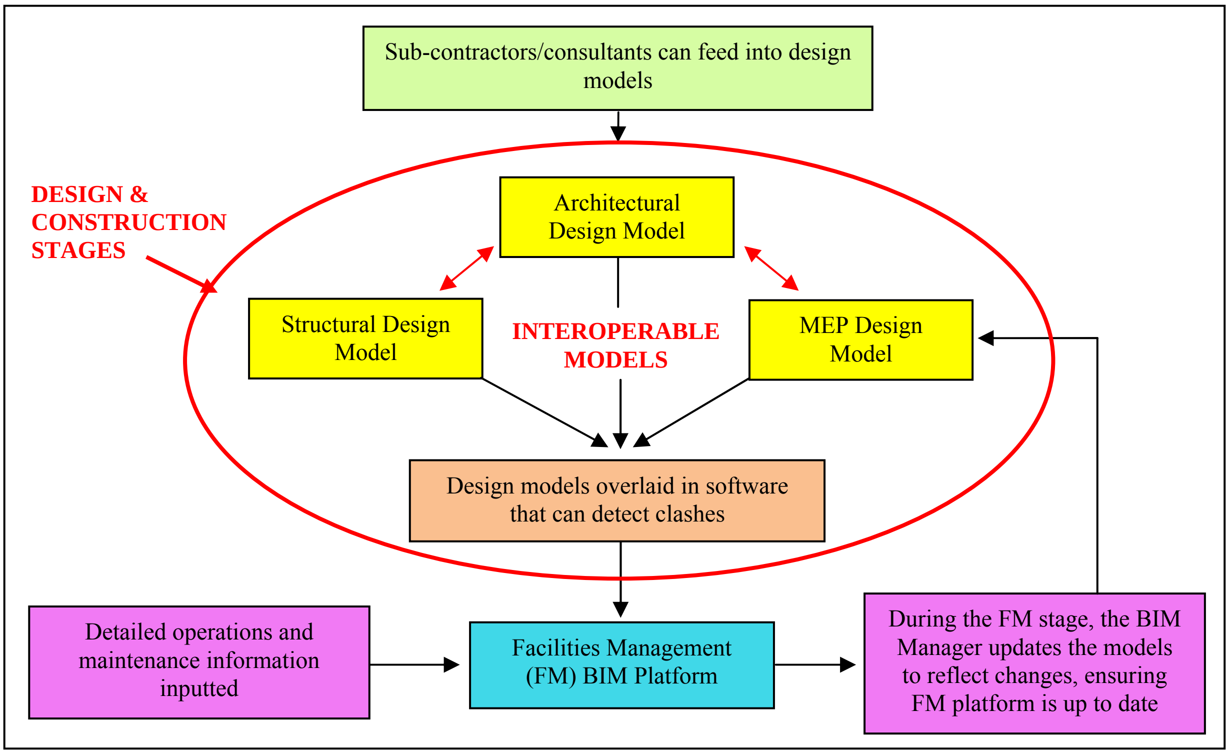

Figure 1: Interoperable BIM Process

The introduction of BIM has been brought about due to a requirement for increased sustainability and productivity within the construction industry (Cabinet Office, 2011). BIM is considered as a means of providing this through an interoperable model, serving as "an integrated and coherent information management strategy" (Meadati, 2009, p.6). It is hoped that this will work to reduce industry fragmentation and provide a smooth flow of information throughout the planning, design, construction and operation phases (McCuen, 2008b), as shown in figure 1.

4.2 BIM Maturity

BIM represents a move away from traditional two dimensional design practices (Sabongi, 2009), as models are developed through the combination of "3D graphical modeling, 4D time modeling and 5D cost modeling" (McCuen, 2009, p.2). Currently, the UK government is targeting all public projects to be delivered to a BIM 'maturity' level 2 by 2016 (BIS; 2011); the various levels achievable are shown within figure 2. Level 2 essentially requires teams to be working collaboratively with 3D BIM, however with no obligation for the 4D programme, 5D cost and operation elements to be incorporated within the model (Construction Manager, 2011). Level 3 represents a fully integrated BIM process, utilising the models full potential (Constructing Excellence, 2011), with the most complex being where clients are able to benefit from lifecycle asset management.

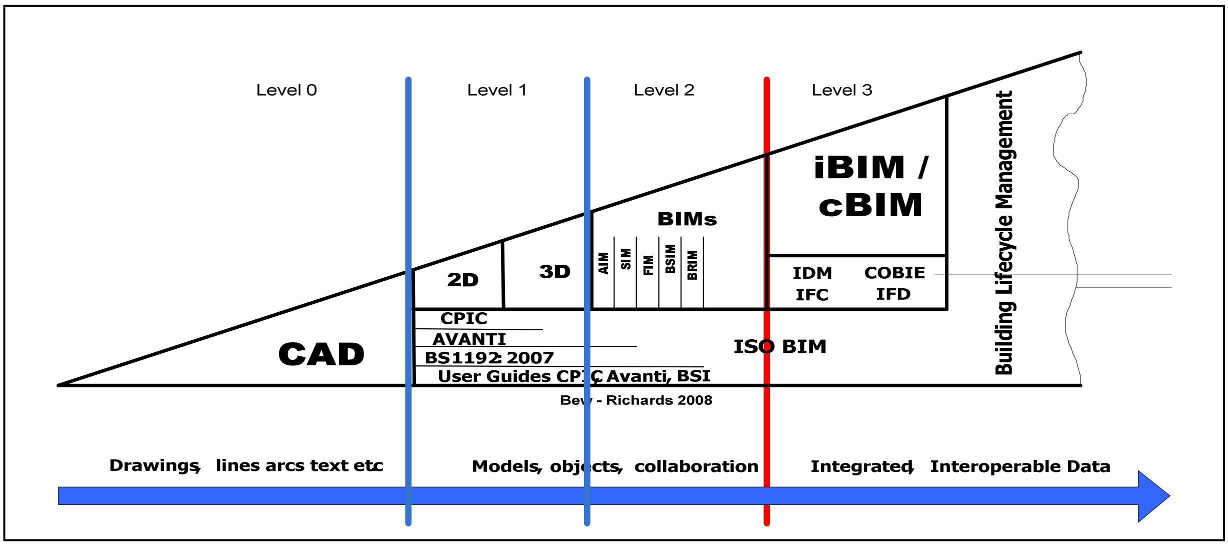

Figure 2: BIM Maturity Diagram (Cabinet Office, 2011)

4.3 5D Cost Estimating and Automatic Quantification

Through level 3 BIM, cost estimating can be carried out through the 5D function, by linking the model to an estimating database (Haque and Mishra, 2007). Hamil (2012b) discusses that this can be done through sources such as Building Cost Information Service (BCIS), to provide high level cost information, which will be useful in the early project stages (BIM Products, 2012). Certain software providers are now publicising that it is possible to develop detailed cost plans through linking a '5D Cost Library' to BIM, which performs the function of an estimating database. A 'master' library can be formed, in addition to several project specific variation libraries, making the process highly productive and easily repeatable (VICO, 2012a). This will allow varying levels of detail to be applied to estimates, depending on the project stage.

Building Information Models are formed of intelligent and multi-dimensional objects; these being objects containing information about the element they are representing, such as quantity and specification details (Azhar et al., 2009). Through this, BIM enables automatic quantification (Greven, 2011, cited in Deutsch, 2011, p.53) and the production of schedules (Woo, 2007), which will largely eliminate the need for manual take-off of buildings during estimating. In addition, design data is interrelated, and therefore an alteration of one element instantly updates anything affected by the change (Sylvester and Dietrich, 2010).

Through automatic quantification, Rundell (2006), reports that human error and inaccurate drawing interpretation during measurement will be eliminated. Hannon (2007) discusses that this will increase efficiency as it will avoid the time consuming and duplicate process of estimators quantifying what designers have already produced, reporting that manual quantification can take 50 – 80% of time during cost estimation. However, as Woo (2007) points out, it will be essential that design information is correct in the first place; an aspect agreed by Patchell (2012), who from his experience working with BIM, states that information extracted from the model is only ever as good as that inputted.

According to McCuen (2008a) estimators with an adequate BIM understanding can benefit from the 5D BIM function and automatic quantification, by creating quicker estimates. This should lead to increased client satisfaction as they are receiving earlier economic feedback on the alternatives available (Pennanen et al., 2011), whilst having a greater understanding of the likely cost influences of design decisions (Greven, 2011, cited in Deutsch, 2011, p.53). However, as pointed out by Kraus et al (2007), without industry standards showing how BIM objects can directly relate to items on estimating databases, problems synchronising the two systems are likely to occur, making it difficult to produce accurate reports. This would result in cost consultants spending time working out differences between models and databases, and rely on the required levels of detail being included within the design.

4.4 Integration and Interoperability

A widely publicised advantage of BIM is the increased collaboration amongst the project team, achievable through use of a centralised model (Sabol, 2008; Sebastian, 2011). It is hoped that communication and information access will be improved through this, therefore reducing the level of work carried out in isolation (Thomson and Miner, 2007 cited in Sabongi, 2009). However, issues within teams may occur as the "highly specialised skills required are currently relatively unique within the industry" (Eastman et al., 2011, p.414), which can cause problems, as different members often possess different BIM capabilities. Eisenmann and Park (2012) found in their research that the team experience level was very important in maximising benefits from BIM, and with little experience, it is possible to see negative results from its implementation. Therefore, they recommend that team ‘experts’ are assigned, as well as a general requirement for sound levels of BIM understanding for those using it.

In addition, Olatunji (2011, p.3) found that interoperability between different software providers is a “major issue that BIM adoption has got to deal with”. Interoperability is the smooth sharing of information across all BIM applications and disciplines involved, which is required for business benefits to be maximised (Arayici, 2008). Howell and Batcheler (2003) agree with this, and state that collaboration can be difficult to achieve due to expectations for the team to adopt one BIM system, which is rare due to the number of companies involved. However, this has reportedly been improved through the establishment of Industry Foundation Classes (IFC), which ensure the effective exchange of information between BIM platforms is achieved through a neutral file format (Iqbal, 2012). Approximately one hundred information exchanges have signed up to the agreement (Solibri, 2012), which will be essential for cost consultants, as without complete interoperability, items will be missed from the model as they are combined and therefore excluded from estimates.

4.5 Provision of Additional Information

As designs develop through BIM, it will be possible to link models with a National Building Standards (NBS) application (NBS, 2012b). This can be used to provide early and reliable specification data, which can be a useful cost management tool (Rider Levett Bucknall, 2012). The 4D function of BIM can also add additional information, in the form of early construction programme details (Meadati, 2009), which may not otherwise have been available. Additional information such as this should help in creating estimates that more accurately reflect the scope of work involved and improve the reliability of cost advice.

Through BIM’s 3D viewer function, the facility can be viewed in an infinite number of ways, from any angle through the model (Sylvester and Dietrich, 2010). Improved visualisation through this should be advantageous to clients, design teams (Haque and Mishra, 2007) and contractors in fully understanding a project’s design (Goldberg, 2007). Cost consultants should therefore have to make fewer assumptions, and as clients can clearly visualise the options available, it has proven to be a beneficial decision making tool (Shennan, 2012), which is hoped will result in fewer cost plan revisions. However, as Sabol (2008) reports, it is possible that too much model detail at early stages could confuse decision making and scenario planning.

4.6 Service Expansion and BIM

Through implementation of BIM, research has shown that it will be possible for cost consultants to offer several additional services. The NBS Group has recently undertaken the Interoperable Carbon Information Modelling project, which is “a new industry project with the aim of creating an everyday design tool to facilitate carbon assessment” (BIM Academy, 2012). NBS believe that this will be a valuable tool for cost consultants to provide clients with cost advice for making lifecycle management decisions (NBS, 2012a). In addition, cost consultancy firms have reported several alternative service provisions that are possible through use of BIM, as part of the cost estimating stage; these include value management, capital allowances and risk analysis (Meadati, 2009).

5. Discussion

Following the detailed literature review, a conceptual framework was formed to record a comprehensive list of advantages and challenges cited for cost consultants using BIM in their working practices; summarised versions of these have been included within Tables 1 and 2. The findings have been grouped into five broad headings, as detailed below.

5.1 Collaborative Working Approach

It can be seen from the conceptual framework created that collaborative working is one of the most commonly reported advantages of using BIM on construction projects. In particular, it has been pointed out that this will be achieved through a centralised model that working through BIM will introduce, with Kraus et al (2007) outlining that collaboration improvements amongst the stakeholders involved will be a key advantage of BIM. Similarly, Popov et al (2006) point out that a lot more is to be gained from BIM as more of the parties involved use it, explaining that overall project integration will improve through BIM, as individual executors will be brought together as teams (Hamil, 2012a), which should maximise the benefits of a centralised model.

5.2 Cost Consultancy Attitudes

The research has shown a fairly low usage of BIM within the UK, with the RICS ‘2011 Building Information Modelling Survey’, reporting only 10% of quantity surveyors as regularly using BIM in working practices, as well as a general level of uncertainty towards it (BCIS, 2011). Whilst there have been fears within the industry that BIM could threaten the viability of the quantity surveying profession through automatic quantification (Olatunji, 2009), cost consultancy firms such as Rider Levett Bucknall (2012), who are currently using BIM, promote a positive attitude and state that it has enhanced their service delivery, including the provision of up to date cost planning. Therefore, a potential reason for the level of uncertainty towards BIM implementation may be due to a lack of personal knowledge and experience. Whilst an improved knowledge base may help individuals to form clearer attitudes towards BIM, as Azhar et al (2007) discuss in their research, this can be a complex process, as there is no single document instructing on its application and usage.

Table 1: Potential advantages for cost consultants using BIM

Potential ADVANTAGES for cost consultants using BIM	Asite, 2012a	Azhar *et al*, 2007	BCIS, 2011	Boon, 2009	Department for BIS, 2011	Goldberg, 2007	Grilo and Jardim-Goncalves, 2010	Hannon, 2007	Haque and Mishra, 2007	Ibrahim *et al*, 2004	Jung and Joo, 2011	Kraus *et al*, 2007	McCuen, 2008a	McCuen, 2009	Moazami, 2011	Olatunji *et al*, 2009	Popov *et al*, 2006	RICS, 2011a	Sabol, 2008	Sebastian, 2011	Shen and Issa, 2010	Tulke *et al*, 2005
DOCUMENTATION																						
Based on current design information													√	√								
Clear audit trail	√																		√			
Quicker documentation preparation																	√					
TEAM COLLABORATION																						
Improve collaboration and communication	√			√	√	√	√	√	√		√	√	√	√	√		√	√	√	√		√
Quick information sharing		√		√			√							√			√		√			√
Good decision making tool				√			√					√	√	√	√		√		√			
Early programme information		√		√					√													
Reduced errors through integrated model	√																					
Earlier supply chain involvement				√	√		√			√	√											
QUANTIFICATION																						
Automatic quantification	√	√		√		√	√	√	√		√	√	√	√	√	√	√	√	√		√	√
Increased consistency and accuracy												√						√	√			√
Export quantities into familiar programmes						√																
Quantities automatically reflect design changes		√					√															
Increase industry productivity				√							√			√				√				
PROJECT UNDERSTANDING																						
Improved visualisation	√	√		√		√	√	√	√		√	√	√	√	√		√		√	√	√	√
DESIGN FACTORS																						
Clash detection	√	√		√			√	√	√			√			√					√		
Develop solutions to design issues							√								√							
Quicker understanding of design change impact							√	√	√		√	√					√			√		
Rigorous option analysis		√		√			√	√	√		√	√			√		√					
Generate 2D drawings				√																		
COST CONSIDERATIONS																						
Greater understanding and confidence in lifecycle costing		√	√	√	√		√		√		√	√			√		√	√	√	√		
Integrating design with cost estimating databases		√				√	√													√		
Possibility to edit BIM estimates						√											√					
More time available for alternative services				√				√								√	√		√			

Table 2: Potential challenges for cost consultants using BIM

Potential CHALLENGES for cost consultants using BIM	Azhar *et al*, 2007	BCIS, 2011	Boon, 2009	Cabinet Office, 2011	Grilo and Jardim-Goncalves, 2010	Hannon, 2007	Haque and Mishra, 2007	Ibrahim *et al*, 2004	Jung and Joo, 2011	Kraus *et al*, 2007	McCuen, 2008a	McCuen, 2009	Olatunji *et al*, 2009	Richards, 2012	RICS, 2011a	Sabol, 2008	Sebastian, 2011	Shen and Issa, 2010
EXPERIENCE																		
Lack of confidence with automation											√							
Varying levels of team knowledge		√	√							√	√				√			
Lack of knowledge held by Quantity Surveyors	√	√					√		√								√	√
Lack of client demand		√																
Lack of training		√																
INTEGRATION																		
Integrating BIM with current practices									√							√		
Investment expense			√		√	√	√			√								
No single set of implementation guidelines	√																	
CHANGE OF PRACTICE																		
Fundamental change														√	√		√	
Uncertainty over data entry control	√																	
Resistance to change			√			√				√					√			
Lifecycle costing putting individuals out of 'comfort zone'			√															
Embrace BIM by 2016				√														
Threaten viability of profession through automatic measurement													√		√			
Detailed models may confuse decisions																√		
SOFTWARE ISSUES																		
Lack of hardware support		√															√	
Different project and company requirements								√									√	√
Interoperability challenges			√		√		√			√		√						
Incorporating unique items										√								
MEASUREMENT AND COST ESTIMATING																		
Detailed model objects required for reliable estimating																√		
Difficulties mapping objects into estimating databases			√			√				√						√		
5D cost function not optimised	√								√								√	
Objects required to reflect RIBA stage																√		
Reduce manual interpretation																		√
Compliance with standard methods of measurement													√					

5.3 Change in Current Practice

The research has shown that many authors, including Tulke et al (2007), have reported that automated measurement should work to increase the speed of updating estimates. In addition, through the potential to overlay designs in software that detects clashes, this should lead to fewer design issues, and in turn the need for fewer cost plan revisions. However, it is important to note that there are certain reservations cost consultants appear to have in connection with the change to an automated process, reflected in an overall slow uptake of BIM amongst quantity surveyors to date (Construction Index, 2012). These include for the development of automatic quantification to comply with the standard method of measurement rules (Olatunji et al., 2009), a lack of confidence in automatically producing something that was previously controlled manually (McCuen, 2008) and through this, the loss of manual interpretation during measurement (Shen and Issa, 2010).

Boon (2009) explains that BIM will allow for the provision of additional information for costing purposes, such as through early supply chain involvement, early programme information and a better understanding of the scheme through improved visualisation. Nonetheless, as Sabol (2008) found in her research, a high level of model detail through such information too early on in a project can potentially confuse design decisions. Whilst this may be true, it appears that standards are now in place to manage the amount of detail included within models, through the Model Progression Specification (MPS). This is a procedure of bringing information together, whilst ensuring that team members are aware of the level of detail they are required to produce information to (VICO, 2012b).

5.4 Additional Service Offerings

Sabol (2008) and Hannon (2007) point out in their research that it will be possible to provide alternative professional services in practice. A key UK government driver for promoting BIM is the opportunity to "derive significant improvements in cost, value and carbon performance through the use of open sharable asset information" (BIM Industry Working Group, 2011, p.15), which lifecycle costing can assist with. Whilst it has been found that additional services such as lifecycle costing exercises are likely to put certain individuals out of their comfort zones (Boon, 2009), it is essential that cost consultants innovate to provide this, as the research has shown that clients are demanding it, whilst other construction professionals perceive it as being a value adding service.

5.5 Additional Challenges

Widespread BIM implementation is likely to present challenges for some people in adapting to changes in traditional practices (Kraus et al., 2007). Several sources show a strong training requirement associated with BIM implementation, which for many firms will represent a challenge, due to the investment costs and time involved (Grilo and Jardim-Goncalves, 2010). As many firms have reported a current lack of client demand, and due to the high investment costs, cost consultancy companies have generally been slow to spend money and time on BIM (BCIS, 2011). Whilst this is understandable, it appears that cost consultants should be aware of BIM's increasing popularity, and consider its influence on their practices in the future, as to ensure that they do not appear behind other professions during BIM's anticipated widespread industry take up (Cabinet Office, 2011; RICS, 2011a).

Hamil (2012a) explains that from his experience, clients appear to be willing to pay higher professional fees for their projects to incorporate BIM, due to the anticipated future benefits to them as long-term facility users, through lifecycle management improvements. However, as Wise (2012) discusses, fees could go down in the long term as companies become more familiar with BIM, and efficiencies within the industry improve (Boon, 2009; McCuen, 2009). Therefore, whilst clients may be willing to pay higher consultancy fees to use BIM on their projects at the present time, as the 'early-investing' firms become more experienced with BIM and are potentially able to decrease future fee proposals, higher costs charged by consultancies making later investment are unlikely to be tolerated. Therefore, companies who adapt later are more likely to have to cover a higher proportion of their BIM investment themselves, or suffer fewer new client commissions.

6. Conclusion and Further Research

The research carried out has generally shown that widespread BIM implementation is anticipated to bring about a new way of working and thinking within the construction industry, in comparison to traditional practices. As supported by the RICS (2011a), it has been found that the usage of BIM is increasing within the UK and seemingly has the capacity of impacting every aspect of the surveying profession, therefore making it essential for cost consultants to adapt and embrace BIM, as to not risk losing ground to others. It is not only BIM's capability of performing automatic and accurate quantification that cost consultants need to be aware of, but also the opportunities that it can offer them, through a solid understanding of BIM's potential advantages and challenges.

Several authors have commented that whilst cost consultants are generally aware of BIM, there is an overall lack of knowledge and understanding of what it is. There was also a requirement shown for training in order to have the capacity of working with BIM in its entirety, and gain the full advantages from it. It will be essential for firms to act promptly, in order to meet the government's 2016 target, as well as to keep future fee proposals competitive and not loose out to 'early investing' companies.

Analysis has shown that BIM has several key advantages to offer cost consultants during the cost estimating stage. As commented by various authors (Azhar et al., 2007; McCuen, 2008a), these are expected to include the time benefits associated with automatic processes and the possibility of accessing additional information, which will be useful in improving the reliability of documentation. The research has displayed potential reservations for using BIM to expand service offerings, such as lifecycle cost estimates and carbon assessments. It appears however, that these are services desired amongst clients and project teams, and therefore the most successful cost consultancy companies in the future are likely to be those who maximise their investment in BIM through offering such skills. However, it is essential that BIM is introduced to organisations as part of a structured implementation plan, with the required levels of sensitivity and potential allocation of 'champions' to help with the process.

Following on from this paper, further research has been undertaken to collect and analyse standpoints of cost consultants and other construction professionals towards the usability and impact of BIM on estimation practices. In addition, it will be critical to explore the change in the cost consultant role during the post contract project stage, as well as the contractual changes that will be brought about.

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A business model for lifecycle service provision through cooperation – Sustainable business management

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Abstract

Holistic sustainable building optimization is a highly complex task which requires the cross-linking of the essential key competences. Construction companies face the challenge to master this cross-linking through cooperation in order to catch up with market demands and sustain customer satisfaction. A new business model for lifecycle service provision has been developed to enable construction companies to successfully accomplish this goal. Drawing upon existing knowledge a theoretical framework is used for the development of the new business model. The framework comprises the following three strategic elements: purpose and value of the business idea, competitive strategy, and realization of the value creation process. This paper is concerned with the latter element and focuses on the role and structure of the business management process to ensure the holistic sustainability of the new business model. Systems theory serves as a scientific framework and the inner structure of the model is guided by sustainable business management theory. The principles of sustainable business management are adapted to the specificity of the construction industry and used to structure the business model. Concluding, an example for the implementation on the different management levels in a construction company is given. In that way this paper enables construction companies to seize research results on sustainable management for their daily business operations.

Keywords: business model, cooperation, lifecycle orientation, networks, sustainable building

1. Introduction

The building industry experiences a transformation process as the framework conditions are changing fundamentally. The existing building stock consumes 50% of total energy. With due regard to an increased shortage in natural resources, especially in fossil fuels, buildings' operation costs take on greater significance. Additionally customers' expectations in regard to comfort are rising including demands about flexibility in use and alteration. Today's project execution is characterized by sequential, highly fragmented processes with many interfaces. Decisions are dominated by short-term yield expectations and mainly focused on initial investment cost. No sustainable building optimization across the lifecycle seizing potential synergies between interdependent subsystems of a building is taking place.

With regard to a pending paradigm change construction companies are encouraged to take a step forward and create sustainable buildings which are attractive for long-term investment. This holistic sustainable building optimization is a highly complex task which requires the cross-linking of the essential key competences. Construction companies face the challenge to master this cross-linking through cooperation with other companies which contribute their expertise in order to catch up with market demands and sustain customer satisfaction. Enabling construction companies to accept the challenge and establish new fields of business requires the development of new business models.

Our research focuses on the development of a new cooperative business model for lifecycle service provision with the objective of delivering sustainable holistic productivity maximization. The requirements and know-how of later stages of a building's lifecycle, like production and operation, have to be considered in the early design stages. Through an interdisciplinary cooperation across trades the knowledge of all project participants can be combined in a synergetic way. A focal enterprise, which acts as system leader, can develop sustainably optimized buildings in cooperation with various specialist contractors, the system suppliers (for example heating, cooling, ventilation, plumbing, electrical installation, facility management, etc.).

2. Research purpose and methodology

The aim of this paper is to enable construction companies to seize research results on sustainable management for their daily business operations in order to catch up with market demands. The new business model harnesses research findings for construction companies and equips them with a strategy for successful implementation. When construction companies take the chance to seize synergies of cooperation and found a network to integrally optimize sustainable buildings in close cooperation with companies of other trades, they need a business model which guides them.

To guarantee the scientific quality of the business model it follows the theoretical framework by Girmscheid (2010), which comprises three strategic elements: purpose and value of the business idea, competitive strategy, and realization of the value creation process. This paper is concerned with the latter element and focuses on the role and structure of the business management processes to ensure the holistic sustainability of the new business model. The following research questions are addressed here:

- Following which principles should the business model be structured to guarantee the sustainability of processes and products?
- How can these principles be adapted to the specificities of the construction industry?
- How can construction companies implement the results?

The development of the business model can be allocated in the hermeneutic science program with the objective of shaping the socio-technical world (Girmscheid 2007). According to the constructivist research approach the model is developed logically-deductively using target-means-relations. The scientific framework is built by systems theory (Bertalanffy 1969), in which the inner structure of the model is guided by sustainable business management theory (Fichter 1998, Schmid 2000, Dyckhoff and Souren 2008). The concept of sustainability is explored in a literature review and principles of sustainable business management are identified. Then the principles of sustainable business management are adapted to the specificity of the construction industry and used to structure the business model. Concluding, an example for the implementation at the different management levels in a construction company is given. In that way this paper enables construction companies to seize research results on sustainable management for their daily business operations.

3. Theoretical framework for business models

The business model is developed according to the theoretical framework for business models by Girmscheid (2010) depicted in Figure 1. Three strategic elements build the business model. The first is the purpose and value of the business idea. According to Lunze (2010) the relevant topics to deal with in connection with this strategic element are: potential target customers, different market stages of the new service offer, justification of the new lifecycle-oriented service offer with lifecycle-cost drivers as well as a system concept of sustainable buildings. Girmscheid and Lunze (2010) therefore developed a construction kit for energetically optimized buildings consisting of various modules and subsystems, which are integrated specifically for each project and combined to form lifecycle service bundles.

The second strategic element of relevance is the competitive strategy which is pursued by the companies delivering the new service offer. Lunze (2010) identified a strategy of differentiation as appropriate to overcome the solely price based competition. The companies involved in the cooperation can create a new field of business as service provider covering the whole life cycle of a building. Through a high degree of customer orientation involving the anticipation of future requirements a discernible customer surplus value can be generated which results in a higher degree of customer retention and constitutes a barrier to market entry for competitors.

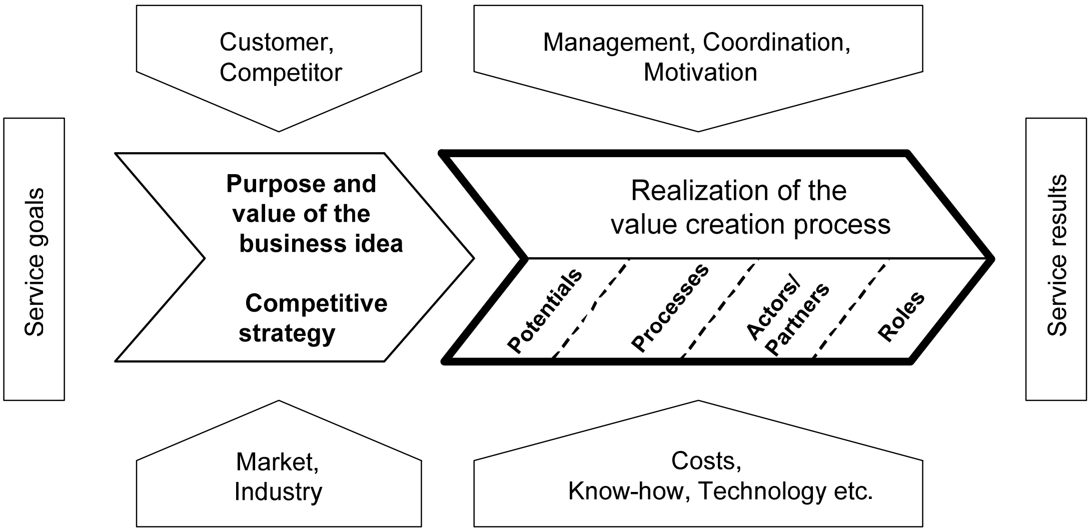

Figure 1: Theoretical framework for business models (Girmscheid 2010)

The third strategic element of the theoretical framework is the realization of the value creation process, which covers four sub-elements: potentials, processes, actors/partners, and roles. This paper focuses on the inner structure of the realization of the value creation process. Figure 2 shows the interplay of the different sub-elements. The sub-element "processes" can be further divided into management processes, support processes, and the service provision process. Here the structure of the management processes for the delivery of holistically, sustainably optimized building is explored.

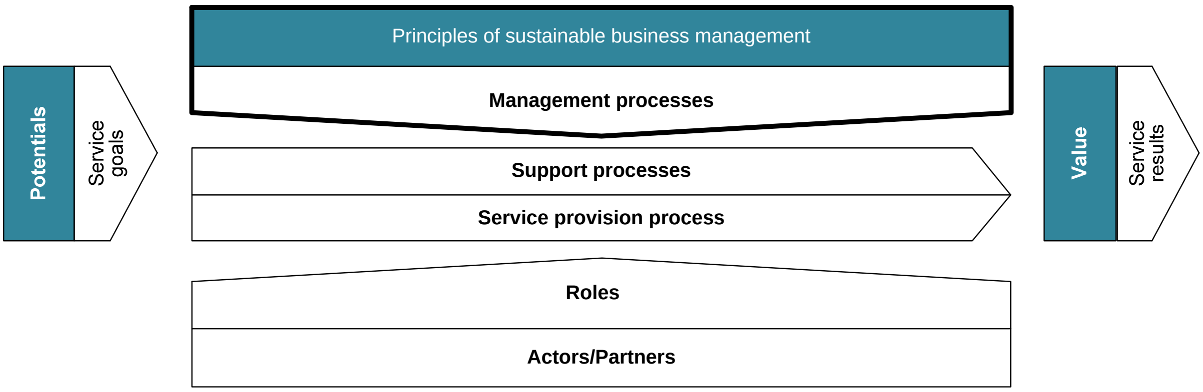

Figure 2: Inner structure of the realization of the value creation process

4. Concept of sustainability

In order to identify principles of sustainable business management the concept of sustainability is examined. This concept has originally been introduced in forestry by Hanns Carl von Carlowitz (1732) as an economic principle to insure a continual disposability of wood. An overview of the more recent concepts in connection with sustainability is shown in Figure 3. A recent definition of sustainable development is given in the Brundtland Report by the World Commission on Environment and Development (1987) as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." This definition implies the requirement to insure the transferability of lifestyle and economic style in space and time, which is derived as a criterion for sustainability. The concept of transferability is linked with the Capital Stock Model developed by the World Bank (Serageldin and Steer 1994). The basic assumption of this model is that total capital stock is subdivided into four categories: artificial, natural, human, and social capital. Four levels of sustainability can be differentiated depending on the degree of substitutability allowed between and within the capital stocks. Weak sustainability calls for the preservation of total capital without regard to its composition. Sensible sustainability demands the preservation of total capital, but with regard to its composition. Substitution between different capital stocks is possible up to a certain degree. Strong sustainability regards the preservation of capital stock subcomponents as necessary and does not allow substitution between the different capital stocks. Lastly, absurdly strong sustainability demands the preservation of capital stock subcomponents and does not allow substitution within the stocks. A similar approach is taken in the well-established Three Pillars Model of sustainability which pursues the reconciliation of environmental, social and economic aspects.

Following the concept of sensible sustainability Dyckhoff and Souren (2008) have formulated general principles of action:

- The functionality of ecological systems must not be impaired by human activities.
- The absorbing capacity of ecological systems has to be recognized.
- Renewable resources should be used in a balanced way with regard to their regeneration rate.
- Non-renewable resources should only be used thus far as resource productivity can be increased or substitution with renewable resource is possible.

Paech (2006) identified two solution approaches to guarantee the adherence to these general principles. The first one is the so-called cultural way which questions the quantitative dimension of economic development. It pursues the adjustment of targets as it questions which amount of production and consumption is really necessary. It is inextricably linked with growth criticism. The alternative solution approach is the technical way which is concerned with qualitative characteristics of economic processes and results. It regards the adjustment of means as an appropriate solution for creating sustainable development. It does not question how much is produced and consumed, but looks for means to create the same output more efficiently and causing less environmental impact. Therefore this approach is in line with growth theory. Following these two approaches three strategies for sustainability (Huber 1995) have been identified. Sufficiency is derived from the cultural solution approach as it demands a change in life style and consumption habits leading to a reduced demand for material commodities. The other two strategies follow the technical way. Efficiency deals with an increase in resource productivity, closed loops of material flow and cascading use of resources. According to Weizsäcker et al. (1997) an improvement of input-output ratios in production by a factor of four to ten is possible through the optimization of products and the value creation process. Consistency targets the re-integration of anthropogenic material and energy flows into the natural cycle. The business model is based on the level of sensible sustainability according to the technical way following the strategies of efficiency and consistency. Derived from these general concepts of sustainability principles for the purpose of business management have to be identified.

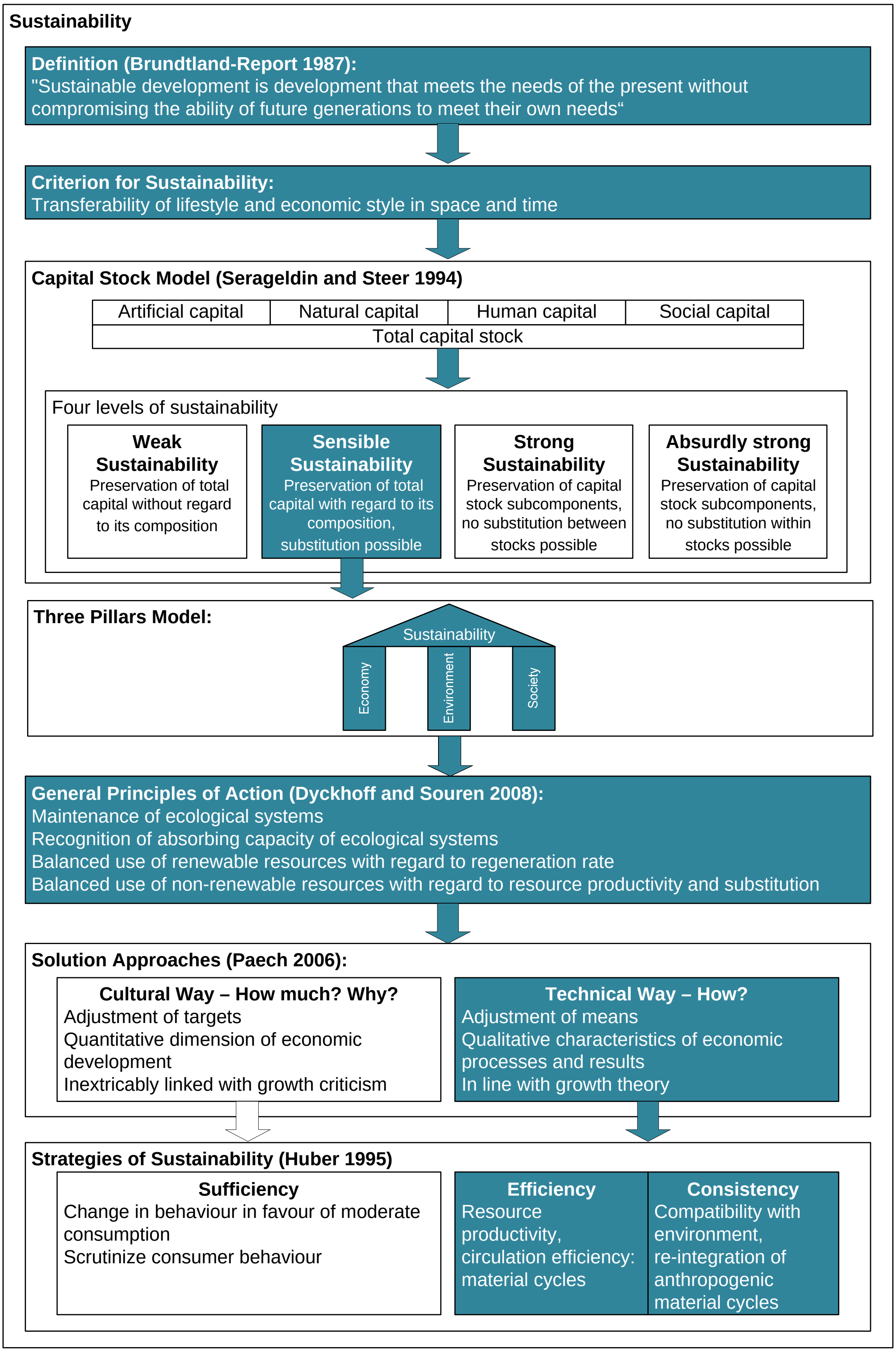

Figure 3: Overview of recent concepts of sustainability

5. Sustainable business management

Derived from the afore-mentioned general concepts of sustainability principles for the purpose of business management have to be identified. These are then used to connect the concept of sustainability with the theoretical framework for business models in order to guarantee a holistic approach towards sustainability encompassing products, construction, and support processes as well as management processes on the normative, strategic, and operative level.

5.1 Principles of sustainable business management

For the specific purpose of business management certain principles of sustainability can be identified in literature (Fichter 1998, Schmid 2000), which ensure not only the sustainability of products but show a holistic approach to sustainability by restructuring business processes. Five principles are identified as relevant for companies in the building industry. These are shown in Figure 4.

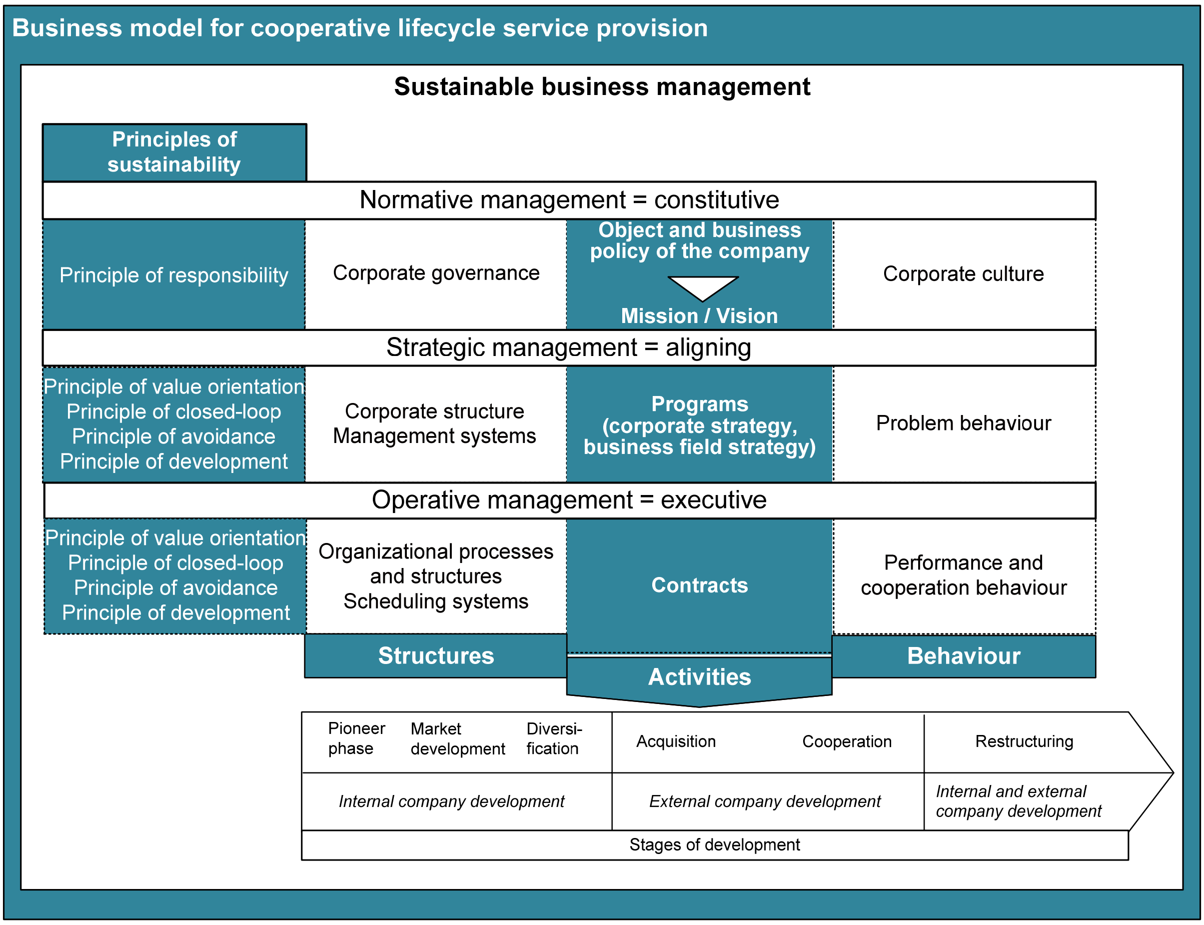

Figure 4: Principles of sustainability and their impact on sustainable business management (cf. Girmscheid 2010)

The **principle of responsibility** relates to corporate governance and corporate culture. It comprises two dimensions: responsibility towards future generations and responsibility within one generation between rich and poor. Future generations should face the same preconditions concerning the ability to satisfy their needs. This is the basic idea of the concept of inter-generational responsibility. Intra-generational responsibility is concerned with the responsibility between industrialized and emergent or developing countries. All human beings should be able to satisfy their basic needs. As the principle of responsibility is part of a value proposition it is constitutive and has to be implemented on the level of normative management.

The other four principles follow on the level of strategic management. They are concerned with corporate structure, management systems and problem behavior. The **principle of value orientation** demands to create a high level of customer value that generates a low level of environmental impact. Therefore the customer requirements have to be evaluated across the entire lifecycle of the building and future requirements have to be anticipated. The **principle of closed-loop** pursues to close loops of material flow and make cascading use of resources. It favors the use of recycled and recyclable materials. The **principle of avoidance** is concerned with avoiding harmful materials in all stages of the lifecycle. Furthermore it claims the avoidance of excessive resource consumption. Renewable resources should be used with regard to their regeneration rate and non-renewable resources should be substituted with renewable resources where possible. The **principle of development** acknowledges the processual character of sustainable development in that it takes account of the dynamically changing market conditions, as well as the political-legal and the social-cultural conditions. Enterprises need to be adaptive to the changing conditions and developable to ensure innovation capacity.

5.2 Implementation in the building industry

When implementing these environmental and social aspects they have to be integrated with the general management system of a company (Figge et al. 2002). One instrument which is regarded as promising for this purpose is the Balanced Scorecard BSC (Kaplan and Norton 1992). Figge et al. (2002) show three ways, how sustainability aspects can be integrated in the BSC to create a so-called Sustainability Balanced Scorecard sBSC. The most appropriate option for construction companies is to integrate sustainability aspects in the standard perspectives which are shown in Table 1.

Table 1: Principles of sustainability – Integration on different management levels

	Customers	*Finances*	*Processes*	*Learning*
Normative level				
Principle of responsibility	*x*	*x*	*x*	*x*
Strategic level				
Principle of value orientation	*x*	*x*		
Principles of closed-loop			*x*	
Principle of avoidance			*x*	
Principle of development				*x*

Normative level

The principle of responsibility affects all perspectives as it influences corporate governance and corporate culture. When implementing it on the normative level, the company's object and business policy have to be expressed in its mission and vision. The questions of how the enterprise contributes to sustainable development with its products and processes and how it helps to reduce carbon emissions have to be answered.

Strategic level

The other principles are subordinate and follow on the strategic level. They determine the formulation of the corporate strategy and the business field strategy.

Perspective of customers

The principle of value orientation affects the perspective of customers as well as finances. Concerning customers the leading questions are to identify current customer requirements and to anticipate future requirements. Then appropriate products and services which satisfy the customer requirements have to be developed.

Perspective of finances

The principle of value orientation also affects the perspective of finances. The enterprise has to specify how it ensures the targeted turnover with its sustainable products and how cash flow is generated. When implementing the principle of value orientation on the strategic level, construction companies have to constitute offering buildings with a high degree of flexibility in use and alteration, with little embodied energy, mainly built with renewable materials. Buildings with low energy consumption during the operation phase and intelligent building services which regulate energy supply and consumption are attractive for long-term investments, because they offer sustained value, especially, if they are embedded in an area with good traffic connection and local amenities.

Perspective of processes

The perspective of processes is concerned with how to reduce material and energy consumption during design and production and how the use of renewable and recycled material can be increased. The principle of closed-loop offers advice for implementation. It suggests the use of recycled and recyclable material, which can be ensured for example through purchasing agreements for metals demanding certificates covering the recycling process. Furthermore wastes from the building industry can be used as secondary raw materials for example in recycling concrete. Already in the design phase principles of construction for selective un-building should be kept in mind. Also proper sinks for non-recyclable and non-reusable materials have to be identified during design. The principle of avoidance suggests additional possibilities to ensure the sustainability of processes in a construction company. Toxic substances have to be avoided across the whole lifecycle. Waste should be reduced for example through the reduction of clippings. Furthermore good insulation can reduce the energy consumption during the operation phase. The embodied energy can be reduced through a production which consumes little energy and uses locally available materials. Construction processes should be designed with regard to reduced earth movements. Compact buildings and light-weight construction can reduce the embodied energy further.

Perspective of learning

The perspective of learning is concerned with the employees. The construction company has to make sure that all employees understand the aims connected to sustainability and that they are motivated to implement them in their daily working routines. A company has to make sure through training and education programmes that the employees have sufficient knowledge about new sustainable technologies. Furthermore the company faces social responsibility towards its employees and has to guarantee an acceptable work life balance especially for young families for example with flexible working hours and part-time jobs. Additionally the employees' safety and working conditions should be of significant importance to the company. The company also faces economic responsibility as employer to safe-guard jobs in a certain region and as tax payer to contribute to public welfare.

6. Conclusion

The afore-going analysis has attempted to demonstrate how construction companies can restructure their business management processes in order to make them more sustainable. Based on a theoretical framework for business models this is one strategic sub-element in the development of a new business model.

This research contributes to the development of sustainable business management by adapting it to the building industry. First, derived from an overview of the concept of sustainability principles of sustainable business management have been identified. Second, it has been shown how to adapt them to the specificities of the construction industry. Third, it has demonstrated one way of how construction companies can implement these principles and integrate sustainability aspects in their existing management systems.

The more general implication of the results of this paper is that business models for sustainable building cannot only focus on the product and the production processes but have to take a wider perspective and integrate business management in the analysis. Apparently there is no one-fits-all-solution for the design of sustainable business management processes. Nevertheless, this paper aims to demonstrate generic principles of sustainable business management and possible implementation strategies for construction companies in order to enable them to restructure their processes in a more sustainable way.

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Diversity Management through board representation in construction

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Abstract

Female board representation is here viewed as one element of diversity management. The construction industry is with other sectors of business facing a legal initiative from the European Commission employing quotas of gender into the corporate boards. Several EU member countries have taken recent legal initiatives, even if the Norwegian (non EU members) reform is the best exercised and studied.

The paper adopts an institutionalism approach to gender and board representation. The framework argues for four interlinked domains of the individual, the enterprise, the board and the environment. Institution in all areas contributes to the experienced constraints.

An illustrative explorative study of Danish Contractors shows that the level of managers in construction seems to have been frozen over the last ten years. In a sample of 10 large contractors the average level of female managers are found to be 12.5% board representation, 4.5% representation in board of directors and 0 CEOs.

Three competing institutions are identified, the hostage, the voluntarist and the politically correct. The present status for the Danish contractors can be characterized as the hostage, as one woman in the board seem to be the present pattern. Whereas the voluntarist institution dominates the external environment domain of the Danish debate. This institution views careers and access to corporate boards a personal matter. It is at present not clear whether the politically correct intervention of quotas, or any others, would come about in Denmark. At least the politically correct institution is in a weak position in the Danish construction industry and in Denmark. An EU reform is therefore a more likely driver for politically correct institutional reform.

Keywords: Board representation, Contractors, Equal opportunities, Gender

1. Introduction

Several comparable countries to Scandinavian countries like Denmark have implemented quotas of gender representation in corporate boards, most notably Norway, but also Belgium, France, and the Netherlands (Hastings 2011). Within EU also Italy and Spain have implemented law regulation. Moreover the EU- commission is lending attention to the issue.

These developments are wake up calls for the construction industry in Denmark as well as elsewhere. In a future knowledge based construction industry a broader mobilisation of human resources would be needed. This even includes the composition of the top level management. Today the construction industry encompasses very few women or minority groups at this level. And as it is likely that the industry in the soon future is forced to bring diversity into the boardrooms, this paper sets out discussing how the industry can anticipate this future situation. Denmark is no exception to this pattern.

The aim of the paper is first to offer an institutionalist theoretical framework for understanding the complex interplay between business environment, enterprise and the individual role, behind board representation (Terjesen et al 2009, Scott 2002). Second to review research on barriers and enablers for womens board representation in business in general and in the construction industry. Third to provide an illustrative example of the status in Danish Construction industry.

The paper thus focuses on women representation in corporate boards as merely one element of a much larger and complex diversity management phenomenon. At present there are two main arguments in favor of increased representation of women in boards:

First HR- approaches claim that diversity in the boards would lead to better performance of the company (Nielsen and Huse 2010).

Second it is claimed that business would benefit through women making specific contributions if they have backgrounds, personalities, and behaviors that are different from men on the board and if they are perceived and treated as different from their male counterparts (Huse 2008).

These two claims remain contested and has been so over a long time(Carter 2010, Terjesen et al 2009).

The European Union has for long attempted to place itself in a leading role on this issue (EU 2012, Hastings 2011, Tomlinson 2011) But despite a number of directives, recommendations and monitoring initiatives starting in 2006 addressing gender equality, women in general remain underrepresented on boards throughout Europe (EU 2012). In response the EU Commission commenced a law initiative commencing with a “Green Paper on Corporate Governance,” in 2011. Followed up by threats on implementing more persuasive measures such as quotas.

The paper start with a theory review, provide a method section and then move on the empirical material on construction in Denmark. The discussion placed the situation in Denmark with three different institutions and the conclusion point to quotas as a possible future avenue for Denmark.

2. Theory

There is a vast literature on diversity management and equal opportunities to membership in corporate boards (Terjesen et al 2009 provide a review). Grosvold and Brammer (2011) and Terjesen et al (2009) propose to draw on theories spanning the domains of the individual, the board, the enterprise and the environment.

This paper adopts an institutional approach to diversity representation in corporate boards. This implies a perspective of gender as “not only an individual property, but also as an institution embedded in the workplace, occupations, and occupational environments through formally defined rules, roles, and responsibilities and the way in which ….individuals think about their social world” (Terjesen et al 2009:325). Gender is understood as “socially constructed roles of and relations between women and men” (Bilimoria and Liang 2012:3). Hopefully such a perspective can help overcome stereotyping men and women, yet at a time also finding commonalities, for examples in the building of professional identies (Dryburgh 1999, Faulkner 2006). Moreover equal opportunities can be viewed as a “social order where men and women share the same opportunities and the same constraints in both the economic and the domestic realm” (Bilimoria and Liang 2012:3).

The institutional mechanisms enabling or constraining the women access to the board are multiple and spans the domains of the individual, the board, the enterprise and the external environment. Terjesen et al (2009) points at gender self-schema and status characteristics by the individual domain. At the board level, Terjesen et al (2009) contend that a board can be viewed as a privileged closed group with its own rules and ways of thinking. Terjesen et al (2009)’s review focuses on group-level processes such as social identity, social network and social cohesion, gendered trust, ingratiation and leadership. In the enterprise domain it is resource dependency, institutional, and agency theories that are prevalent. Finally in the external environment it is again the institutional that is mentioned, but also critical theory.

Grosvold & Brammer (2011) adds to the external environment element by pointing at the role of national institutional systems. Grosvold & Drammen advocate the macro-micro linkages in their investigation of national institutional systems and their impact on board representation. They observe that gender differentiation, i.e. the manner in which gender and the differences between gender is assigned meaning is different in different national domains, leading to different likeness that women would obtain senior management position. The Nordic European and Eastern European cultural clusters have lower levels of gender differentiation compared to the Anglo-Saxon and Latin cultural cluster (Grosvold & Brammer 2011:121). They find linkages between the market organisation and board representation of women. Liberal market economies (such as US) have a higher proportion of women on their boards than do coordinated markets economies(such as Denmark) by around two percentage points in their analysis (Grosvold & Drammen 2011:311).

2.1 Barriers and Enablers for Equal Opportunity

Past and present research on equal opportunities on boards have developed a range of explanations for barriers and enablers and carried out evaluations of a range of efforts (see for example Barnard et al 2010, Terjesen et al 2009). The discussion below is carried out first looking at voluntary measures and secondly on obligatory. It has been chosen to select a few examples of each type.

2.2 Voluntary efforts

Maybe especially in liberal economies, such as US (Grosvold & Brammer 2011), the companies and individuals have taken a number of voluntary initiatives to improve equal opportunities. This encompasses developing a corporate governance code (EU 2012), either by complying with a societally present or by making it internally. Voluntary efforts also encompasses company programs such as leadership development (Hopkins et al 2008), mentoring programs, flexible work hours and on-site childcare, which could help women and men in developing and advancing their careers as well as achieving work–life balance (Michailidis et al 2012). Raiden and Caven (2011) find widespread informal practices in their UK construction investigation. As pointed out by Barnard et al (2010) there is a risk when designing such efforts to fall back to essentialists notions of gender, for example assuming that child care would be the women's responsibility, a finding similar to Raiden and Caven 2011. And thereby reproducing stereotypes.

External voluntary effort would typically encompass networking. Recruitment for board memberships is often described as a network activity where existing member of the boards recruit their contacts and protégées (Heemskerk E. and Fennema M.2009). Networks of (male) managers with for example similar educational background would thus obtain social cohesion, often described as an 'old boys network'. Heemskerk and Fennema (2009) find that the social cohesion in the Dutch business elite declined between 1976 and 2001 and norms of corporate governance have become blurred. Therefore the elite network cannot act as creating trust among the corporate elite. As a result, one could expect a more diverse recruitment for the elite might occur. Such development could be supported by female managers forming networks, the creation of recruitment databases etc. In a Dutch context however Heemskerk and Fennema (2009) experience the intervention of a law reform, making female representation in boards obligatory, leaving it redundant to speculate whether the more open network would voluntarily have acted in new ways. Barnard et al (2010) point out that even if women's networks are important the making of the networks are considered laborious and engineering professions might not consider it as part of their job. O'Neill et al (2011) demonstrate how networking is part of a voluntary institution as the strategic managers interviewed placed responsibility for women's career advancement upon the individual. However the situation was no different with the women employees interviewed. Both groups choose to overlook the firm's male-dominated culture and other organizational constraints.

2.3 Obligatory Efforts

The obligatory means are typically public regulations intervening in the business domain, as other labour market regulation. In general these kinds of interventions are as old as the industrial society. Equal opportunity legislation is in place in a number of societies, including the EU.

In the later years the most debated and also the one used to an increasing degree is the use of quotas of gender in board representation. The most well exercised, oldest and most studied is the quota in Norway (Matsa and Miller 2011, Nielsen, S. and Huse, M. 2010, Storvik and Teigen 2010)

After a long preparation phase the Norwegian government implemented a quota of 40% of female representation in corporate boards in 2003 (Storvik and Teigen 2010). According to Storvik and Teigen (2010) the enterprises were given four years to meet the quota, a number of data bases was established for prospective female board members to support the recruitment process. The Norwegian employers' association created a training program aimed at company employees. After an initial phase without sanction, the Norwegian law came to encompass sanctions supporting the implementation. The most radical sanction enabled by the law was the forced dissolution of non compliant companies. When there were no sanctions in the initial phase, companies did not widely implement the policy on a voluntary basis. Storvik and Teigen (2010:3) notes that

"Seven years after it was passed, the quota is widely accepted in Norwegian politics and society. The employers' association has not reported any problems and interviews with business leaders suggest that the policy is no longer controversial"

If the quota has become successfully institutionalized in Norway it remains controversial outside Norway (Grosvold & Brammer 2011). More specifically it is debated whether the female quotas are instrumental for business. Matsa & Miller (2011) compares Norwegian companies operating under the law of quotas to other Scandinavian companies and finds that firms affected by the quotas undertook fewer workforce reductions than comparison firms, increasing relative labor costs and employment levels and reducing short-term profits. Moreover they find that the boards appear to be affecting corporate strategy in part by selecting likeminded executives. Matsa & Miller (2011) suggests on this basis that female managers may be more stakeholder or long-term oriented than their male counterparts (Matsa & Miller 2011).

Kossowska et al (2005) using public statistical data, finds that large Danish companies with female board representation either perform better or the same as other Danish companies over the period 1992-2001. Carter et al (2010) investigates large US corporations and cannot demonstrate a link between female representation and financial performance. Nielsen & Huse (2010) notes that many investigations on the issue remain descriptive, quantitative and superficial. Nielsen & Huse (2010) themselves uses a survey of 201 Norwegian firms of all sizes, without control group. They suggest that their findings support that the ratio of women directors is positively associated with board strategic control, with decreased level of conflict and with commencing board development activities improving the quality of board work. Nielsen & Huse (2010) contend that women's ability to make a contribution to the board relates to their different leadership styles.

As an overall status of these voluntary and obligatory means, it can be observed that the outcomes of these efforts are mixed and contested (Barnard et al 2010, Bilimoria & Liang 2012), but/and that the slow expansion of women representation in boards are one of the more disappointing development (Bilimoria & Liang 2012), whereas the expansion of obligatory quotas move the public debate and the research in new more promising directions.

3. Method

The paper adopts an institutionalist interpretivist approach to gender and representation in boards (Bilimoria & Liang 2012, Scott 2001, Terjesen et al 2009). It presents a first small exploratory screening of board representation at contractors in Denmark. The companies for the board investigation were selected using a website of the thousand largest Danish enterprises (top1000.dk 2012). The ten contractors covers the four largest general contractors, MTH, Pihl, NCC and Hoffman/Veidekke, two foundation and earthworks contractors Arkil and Aarsleff, and five technical contractors Bravida, YIT, Kemp & Lauritsen and Eltek Networks. This selection gives coverage of sub domains within contracting without engaging with SMEs as it is assumed that the larger companies would be the leading on issues of diversity. The companies are listed shareholder companies, whose activities are regulated by law. Shareholder companies need to have elected employee representatives in their board, and those are accounted for below. They are however not treated specifically as they do not make a gender difference in this case. Three of the selected companied are owned by multinational companies with corporate headquarter abroad; NCC, Hoffmann/Veidekke and YIT, but is the Danish management which is investigated here.

As background material is used a Danish study of diversity management in construction, which qualitative part studied a diversity effort at a large Danish contractor (Kamp 2005, 2007).

4. Empirical Study

The development in Denmark when it comes to gender and gender representation in management is at best ambiguous. While there are a solid basis of labour market and employment for both genders the pay and representation stay asymmetric (EU 2012). In 2011 the association of managers in Denmark announced that they had reached 25% female membership amongst their 100, 000 members (Lederne 2011). This can be compared to 12% in 1991. Amongst engineers, which are a central recruitment group for managers in construction, the female membership in 2012 was 20%. However this glosses over differences between different sub engineering areas such as construction. Kamp (2005) found that among engineering students 22% was women, with indications of growth among building engineers, a growth which appears to have been recruited predominantly by consulting engineering and public units.

Holt et al (2006) found that Danish construction encompasses the lowest female representation in executive boards and as CEOs (2%) and that construction sector has 10% women employed with some subsector (bricklayers) virtually without women employees or manager. A Danish investigation of the 2300 major companies covering the period 1992-2001 (Kossowska et al 2005) showed an unchanged low level of female managers and members of boards in construction. IFKA (2007) arrived at the same result, finding that 70% of the investigated 100 companies in construction answers they have 0-15% female managers. The Kossowska et al (2005) investigation showed an unclear answer to the issue of possible linkage between women at board level and performance as Kossowska et al (2005) concludes that either enterprises employing women in the board of directors or higher level of management have performed better or there is no difference. At least, Kossowska et al (2005) concludes, they have not performed worse (!).

IFKA (2007) points at lack of systematic recruitment policies in construction companies as explanation for the low level of female managers, IFKA (2007) thus finds that a mere 2% of the investigated construction firms are systematically recruiting women.

In figure 1 is entered the female representation at the four largest general contractors, MTH, Pihl, NCC and Hoffman/Veidekke, two foundation and earthworks contractors Arkil and Aarsleff, and five technical contractors Bravida, YIT, Kemp &Lauritsen and Eltek Networks.

	Board			**Board of Directors**			CEO	
	No Men	No Women	%	No. Men	No. Women	%	No. Men	No. Women
MTH	9	1		3	1		1	
E. Pihl & Søn	4	2		5			1	
Per Aarsleff	6			2			1	
NCC	5	1		2			1	
Arkil Holding	6	2		2			1	
Hoffmann	5			1			1	
Bravida- DK	5			2			1	
YIT	4	1		1			1	
Kemp & Lauritsen	8			1			1	
Eltel Networks	4	1		2			1	
Total	56	8	12.5	21	1	4.5	10	0

Figure 1: Female representation at Danish Contractors

Where the above figure focus on the board domain and partly on the enterprise, Kamp (2007) provide an insight in the institutions present among the operational site managers. The contractor had at the time of investigation around 25% of site managers being female. Nevertheless the contractors projects and operational level is heavily male dominated. The female managers struggle to be understood and recognised as professionals, especially in the beginning of their career. It is laborious and meticulous effort to build a professional identy as woman and project manager, counting behavior, language and appearance (Kamp 2007). They try to obtain respect by being serious, fair and competent. This demands time and energy and is probably why the female project managers do not engage actively in debates on strategic management position or even board representation (Kamp 2007).

Styhre (2011) in his study of Swedish site managers find that the site manager role is enacted as a omnipresent figure having full control of the situation, always in the position to take care of emerging and unforeseen events, and spending long hours at work. He studies 19 male site managers in three contractors, which do not employ any female site managers. Styhre (2011)-s study reveals the site manager, as somebody capable of enduring any work situation, as someone capable of doing crisis management: handling unanticipated events and who is celebrating the 'virtue' of overworking. Styhre points out that the site management role are reproducing gender ideologies, imposing expectations on individual site managers, and erecting entry barriers for e.g. women or individuals not willing to forsake family life. Many of Styhre (2011)-s interviewees are very experienced site managers, with many years in the business behind them, and these managers voice their concerns over the site management work ethos as a concern for the coming generations. This paternalistic approach is on the other hand confirmed by Raiden & Coven (2011) who reports younger site managers who counter to the stereotypical view voice strong need to operate locally in order to stay close to home and family and even occasions where female respondents prioritise their career ambitions.

5. Discussion

According to the institutionalist argument the explanations for the asymmetric representation are to be found in the intersecting domains of individual-enterprise-board-environment. It was found that the present Danish construction enterprise board institution can be characterised as one of 'taking hostages'. At maximum one woman is represented in the board, and not as member of the strategic management nor as CEO.

The exploratory screening of ten companies showed that the selected contractors are behind Danish average as well as EU-27 average. The sample does not encompass a single female CEO and only one board encompasses more than one women representative. As Terjesen et al (2009) point out the legitimacy and effects of the presence is likely to change once there is two or three representatives.

Kossowska et al (2005) finds 10.3% women in Danish boards based on 81 enterprises in construction, and 4.8 % women in top management which are results similar to the present one, yet it is measured 11 years earlier in 2001. EU (2012) find the DK share in boards of listed companies 16% (January 2012) across sectors compared to Swedish 25% and EU-27 14%.

The development can be seen as a competition between to institutions of gender representation. One, the voluntarist, places the initiative and responsibility with the individual woman, who has to build up the necessary competences, create the necessary network, maintain a work-life balance. And another, the politically correct, which calls for a set of institutional set ups to assure women equal opportunities in all domains. This institution encompasses educational pipelines, recruitment policies, talent management and a portfolio of public regulation, including law regulated quotas for board representation. Actually the educational and labour market pipelines are providing the qualified women for the Danish construction industry at a rate at almost 50% of both craft, engineer and business educated workforce.

The present state of the studied construction enterprises could be viewed as dominated by the voluntarist institution. Both Styhre (2011) and Kamp (2007) provide support for what can be understood as a silent consent to this institution among the operational site managers of both sexes. It also appears to be widely accepted in the industry that very few women are represented at a high level and it can even be speculated that the women that are managers at lower levels and have potential for climbing further up, themselves are spokesperson for the voluntarist institution (which would be more active than silent consent). But maybe it is more precise to describe the voluntarist institution as one who has foothold in the external environment domain. At least the public Danish debate amongst female managers predominantly gives voices to this institution, whereas the politically correct is heavily critizised. This even encompasses the present Danish centre left government who want to recommence dialogue with social parties to create a 'Danish model'. That comparable European countries have begun supporting the politically correct institution is not yet of sufficient importance. Apart from Norway outside the EU, Belgium, France, Italy, the Netherlands and Spain all EU countries have all introduced laws that require gender quotas for company boards, and France alone accounts for around half the increase in female European corporate board members over the past twelve months (EU 2012, press release). France has thus improved 10% in one year, 2011, as the law was implemented in January 2011 and moved to 22%, way beyond the Danish status (Brunet and Dumas 2012). Similarly the Netherlands law reform has improved from 9 % in 2009 (Heemskerk and Fennema 2009) growing to 19% in 2012 (EU 2012).

In a similar vein the voluntary and obligatory types of efforts reviewed, each supporting the two institutions of the voluntary and the politically correct, might be well stabilized and normalized on restricted arenas (i.e. Norway Storvik and Teigen 2010) but are on a larger European and US arena accompanied with mixed and contested research on their results and impact (Barnard et al 2010, Bilimoria & Liang 2012.

Meanwhile the female project managers and at other functions at lower levels by the contractors are, as Kamp (2007) evaluated it, busy demonstrating that they are serious, meticulous, professional partners in their projects. And the discussions on board representation they leave to others.

Even if not analysed it here future change might either strengthen the voluntaristic institution, the politically correct or even show a possible third path. In the framework of the politically correct institution reforms that can be employed from the public side might be a dangerous sleeping pill in coordinated economies. As pointed out be Gronvold and Brammer (2011), in coordinated economies state initiatives might be needed. It can be added that the private players might tend to await exactly that, and postpone single enterprise initiatives.

6. Conclusion

The level of female managers and board members in construction in Denmark seem to have frozen over the period of 2001-2012 at a level lower than average EU-27. This appears to be supported by a voluntarist institution impacting of the intersected domains of the enterprise, the boards, the external environment and the individual. This institution counts it as legitimate that women themselves have to climb up the career ladder. At present the slowly increasing amount of women engineers in construction provides a tension with the little amount of women at higher management levels. This tension is unlikely by itself to create the institutional change, but the presence of qualified talented managers at lower levels provide a strong basis for a governmental reform changing the institution once and for all.

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Business Strategies for Architectural Firms: Type versus Capabilities

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Abstract

There is now no shortage of strategic management advice on offer to architectural firms, from either consultants or books – although one may have to search for it. Much of this advice is based on typologies of architectural firms. This allows the consultant or the reader to assign a firm to one or another type, and read off the strategic recommendation. The simplicity and decisiveness of these typologies gives them a certain authority. In this article we argue that the typology of architectural firms is unfounded, lacking convincing empirical evidence and sufficient complexity to reflect the actual nature of architectural firms and the markets they operate in. Specifically, while most strategy literature is written as if there are relatively few sellers and many buyers, architects must compete among many sellers for work from comparatively few buyers.

Drawing on the language of the resource based view of strategic management (RBV), we offer an alternative account of strategy options for architectural firms based on understanding the market in terms of demand, competition and segmentation, and the firm in terms of values, capabilities, differentiation, and branding. We suggest that the typological systems do not allow for sufficient differentiation, and that architectural firms must strive to present themselves as having identifiable differences in capabilities from their many competitors. RBV also allows a architects to specifically address issues such as market segmentation, diversification and specialisation.

Keywords: professional service firms, strategic management, firm typology, architectural design expertise

1. Architectural services: What's in a Type?

There is now no shortage of strategic management advice on offer to architectural firms, from either consultants, papers or reference books – although one may have to search for it. Much of this advice is based on typologies of architectural firms. This allows the consultant or the reader to assign a firm to one or another type, and read off the strategic recommendation. The simplicity and decisiveness of these typologies gives them a certain authority. In this article the authors argue that this use of type are unfounded, lacking convincing empirical evidence and sufficient complexity to reflect the actual nature of architectural firms and the markets they operate in. This paper makes a call for increasing the understanding architectural practices and calls for empirical studies to provide well founded and less idiosyncratic directions.

1.1 Architectural firm as a business

Architecture is a business in which technical knowledge, management, and an understanding of business are as important as design. In this paper type refers not to the type or kind of architecture produced such as by functional types, morphological types or historical types but to the forms of business and organizational constitution of architectural firms. A search for business modelling and strategies for architects academic search using EBSCO, Science Direct and the Web of Knowledge search engines yielded results dating back to the early 1970s applying generic business sense architectural firms, but it was not until the late 1970s that could find evidence for market research specifically for architectural firms "Identifying your markets of future" (1978). Since, a number of architectural business typologies have emerged some of which are discussed here.

Much of the management literature applied to the practice of architecture takes a single-sided view on the managing on delivering a building, service or product and less on the *market positions* or *strategic management.* Market positioning (or super-positioning) refers to the coupling of these two variables – management as delivery and management as business strategy (Smyth, 2003). This paper is concerned with the second aspect of management.

The practice of architecture is often narrowly defined and misunderstood, in some cases is located in the field of arts and humanities (Lawson, 2006), in other cases as a service industry and business driven (Nordenflycht, 2010). Business and marketing literature tends to ignore the unique and complex nature or architecture as a design oriented service and common idiosyncrasies of the profession. Historically it was Le Corbusier the first to identify the need to develop a brand and business niche in architecture as he consciously developed a 'signature' especially by making use of publishing and media with glossy books bound in landscape format accommodating thus drawings and sketches in a more enticing format for the reader and using typography from pre-first world war, German art movement, the Werkbund providing promotional material to his ideas and practice (Boyer, 2011).

In more recent times competitive advantage for architects doe not only rely on market positioning but on an array of business performance and productivity outcomes (Tinnilä & Vepsäläinen, 1995). Perhaps all this tilting too heavily on IT and computer systems with the advent of cad CAD, BIM and the Internet where technology adoption present not just a knowledge challenge but a cultural challenge. The following is a review and critique of practice typologies.

2. Firm Typologies

The most authoritative and well known and fully developed system of firm types was developed in the 1980's by the Coxe Group firm of management consultants, including Weld Coxe, David Maister, and Brian J. Lewis (Coxe, 1987; Lewis, 1988). The Coxe Group typology was developed drawing from Maister's generic typology of professional service firms (1985), and was based on the premise that *"there are observable categories of consulting engineering firms, and each category has a definable and consistent set of management strategies."* (Maister 1982 and Maister in Lewis, 1988) Maister referred to Vollmer (1966). The Coxe typology is part of a larger consultancy system called *"superpositioning"*. The typology is based on a division of firms into three categories of *"design technologies"* and two categories of *"organizational values"* yielding 6 types.

Table 1: The Coxe Typology

Coxe et al		*Organizational Values*	
		Practice Centred Business	*Business Centred Practice*
Design Technologies	*Strong Delivery*	*A*	*B*
	Strong Service	*C*	*D*
	Strong Idea	*E*	*F*

Strong Delivery technologies provide efficient service on routine projects for product oriented clients. *Strong Service* technologies provide experienced and reliable services for complex projects. *Strong Idea* technologies provide deliver singular expertise or innovation for unique projects. Although *Strong Idea* firms are associated by most readers with architectural stars, firms delivering highly specialized or niche expertise may also fall into this category. Practice centred businesses are driven by professionals who are devoted to high quality service and the exercise of their professional expertise. Business centred practices are driven by bottom line, financial rewards.

A firm's type is determined by answers to 9 questions. These concern:

1. Ownership
2. Firm-wide decision making
3. Staffing
4. Marketing
5. Organization
6. Project related decisions
7. Reward structure
8. Pricing
9. Clients (quality preferences)

Each question has 6 possible answers or attributes, and these answers correspond to the 6 types. Each type represents a unique match between firm structure, policies, and goals. Thus the characteristics of a prize *winning firm (brand)* marketing Strong Ideas will be quite different from those of a highly profitable firm marketing reliability, budget and time control *all attributes forming a brand* (i.e., Strong Delivery). Together these six types are intended to cover all possible viable forms of architectural, engineering and design practices. Success according to the Coxe Group, lies in bringing the characteristics of your firm into compliance with one or another of the six ideal types. Any firm wishing to be successful must conform to the type it most resembles. Evolution from one type to another is deemed possible along a *(linear)* unidirectional line from idea through service to delivery and from practice to business – i.e., along a line of decay from idealistic to commercial to crassly commercial. It is as if as architects age they loose their interest in art and gain an interest in golf and income but also perhaps in sustaining more established practices employing a larger number of staff.

The Coxe typology is therefore *normative.* It is not an attempt to describe architecture firms as we find them, but rather a scheme intended to outline the *only possible successful configurations* available to architectural firms.

By the mid '90's the Coxe Group had advised over 600 firms using the *Superpositioning system* (Cheung, 1994). The Coxe typology corresponds well to 'common sense' and to widely held stereotypes of architects. It has become familiar to many architects and is often referred to in the literature on design management. However, it is often abbreviated to the three design technologies: Strong Idea, Strong Service, and Strong Delivery. Unfortunately, the questionnaire, the ideas and theories built into it remain less well known.

Several authors have developed architectural firm typologies since Coxe et al., and the most important of these will be discussed below. We will show that these are reducible to the Coxe typology, and offer little additional insight.

2.1 The Winch & Schneider Typology

In the 1990's Graham Winch and Eric Schneider developed an alternative typological system to facilitate architects in positioning themselves in their market. Their system was a reaction to the Coxe group system (Winch & Schneider, 1993). Following Porter's (1981) approach to strategic management, they focused on market characteristics rather than characteristics of the firm. The typology is intended to yield a mapping of the market in terms of four market positions, yet their type labels bare a clear resemblance to those of the Coxe group system.

Table 2: The Winch & Schneider Typology

Winch & Schneider		*Project Complexity*	
		Simple	*Complex*
Quality Preference	*Client Review*	*Strong Delivery*	*Strong Experience*
	Peer Review	*Strong Ambition*	*Strong Ideas*

Winch & Schneider's (1993) Strong Delivery, Strong Experience, and Strong Ideas correspond well to Coxe's Strong Delivery, Strong Service, and Strong Ideas (although Winch & Schneider's Strong Ideas type is more closely associated with distinctive architectural style). Their Strong Ambition is simply a smaller or start-up form of the Strong Ideas type. If we correlate Winch & Schneider's *'project complexity'* with Coxe's clients and their *'quality preference'* with marketing, than we get exactly the same result in the matrix. Winch & Schneider's scheme is therefore simply a reduction of the Coxe scheme to those attributes that describe the interaction between the firm and its market. Winch & Schneider agree with the Coxe Group that firms are unlikely to be able to perform strongly in three or all four of the markets with any consistency. Firms, we are told should focus their strengths. However, they offer no empirical data for their conclusions.

2.2 The Allinson Typology

Kenneth Allinson also developed a typology of firms that appears initially independent of the Coxe typology (Allinson, 1997). However references to the Coxe typology in earlier work (Allinson, 1993) suggest that an awareness of it played a role in Allison's thinking. Allinson's types Signature Practice and Delivery firm are equivalent to Coxe's types Strong Idea and Strong Delivery. A *Consultancy* is equivalent to a *(1) 'practice'* centred Strong Service firm and an *Expert Practice* is a (2) *'business'* centred Strong Service.

Table 3: The Allinson Typology

Allinson		*Power Structure*	
		Consensus Seeking	*Power Seeking*
Problem Orientation	*Problem Finding*	*Consultancy*	*Signature Practice*
	Problem Solving	*Expert Practice*	*Delivery Firm*

Allinson's system relies on firm characteristics rather than market characteristics: *'problem orientation'* and *'power structure'*. If we correlate power structure to Coxe's Firm-wide decision making, and problem orientation to the departmentalization as reflected in Coxe's organisation, then once again we arrive at an identical matrix. Thus here too, we have a simple reduction of the Coxe typology.

2.3 The De Bont Typology

On behalf of Bureau De Bont, Bouwdewijn & Broekhuizen developed what appears to be an independent typology (Boudewijn & Broekhuizen, 2002). Here the relationships between the characteristics listed by Bouwdewijn & Broekhuizen and those listed by Coxe is not so clear. There are no clear synonyms and the three characteristics by which the firms are typed are not synonymous with any of Coxe's. De Bont's characteristic manner of working includes elements that fall under both Coxe's organization and project related decision making. Core quality includes elements that fall under Coxe's general descriptions of the design technologies, as does basic principle. On a holistic comparison of the descriptions of the types, De Bont's types correspond well to Coxe's design technologies. Indeed it has been claimed by other authors that their system was based on that of Coxe (Loonen, 2004).

Table 4: The De Bont Typology

De Bont	*Basic Principle*	*Core Quality*	*Characteristic Manner of Working*
Studio	*My idea and creativity*	*Innovative*	*Improvisational*
Firm	*Our Client Risk Management (Process)*	*Relation(s)*	*Project Based*
Business	*The product and engineering*	*Product Management*	*Routine*

Note that *firm* and *business* practice type denotes a consulting with Strong Delivery (i.e. risk management) whereas Studio would align closer to Strong Ideas (i.e. my idea and creativity, innovative and improvisational). Similar practices to *'studio'* type often are referred as atelier, büro and workshop, often named after the principal. Leon Van Schaik has been an avid supporter of the studio/practice as influential in the way built environment shapes our cities. His advice to studio type practice are found in Mastering Architecture (Schaik, 2005) and emergence of sophisticated markets (Schaik, London, & George, 2010).

2.4 The HLB Nannen Advies Typology

In 2004, Nannen Advies (an accounting firm) was commissioned by the Bond van Nederlandse Architecten to do a study of architectural firms in the Northern Region of the Netherlands. In this study B.M.H. Loonen (Loonen, 2004) combined Henry Mintzberg's (1980) typology of organizational structures with the Winch & Schneider typology of firms interpreted as market positions he derives 6 types of firm. He provides no argument or evidence for his correlations.

Reference to Mintzberg's types allows connections to be made to a large body of organizational and strategic management knowledge. Mintzberg himself *discussed the tensions between flexibility loved by some architects and the imperatives of administration*

Table 5: The Nannen Typology

HLB Nannen Advies		*Organizational Structure**		
		Simple Structure	*Professional Bureaucracy*	*Adhocracy*
*Market Position***	*Strong Delivery*	*Type A.1*		
	Strong Ambition	*Type A.2*		*Type C.2*
	Strong Experience		*Type B.3*	
	Strong Idea		*Type B.4*	*Type C.4*

** From (Mintzberg, 1980)*

*** From (Winch & Schneider, 1993)*

which emerge as a firm grows larger – the tensions between *adhocracy* and *machine bureaucracy* (Mintzberg, Otis, Shamsie, & Waters, 1988). And this is indeed reflected in the Nannen typology as Types B.3 and B.4. Mintzberg also acknowledges a typical attribute of architectural firms such as ARCOP staffed with highly trained professionals, the distinctions between *the machine* and *professional bureaucracies* is the level of *staff training* (Mintzberg, 1980). We may therefore assume that he would consider the appropriate structure for an architectural firm to be a professional rather than a machine bureaucracy. It must be noted that in 1965, when ARCOP, the firm Mintzberg studied, was feeling the pull towards bureaucracy most strongly it had over 140 employees and an annual billing of $3,000,000 (in 1980 Canadian Dollars). A few Austalian and Dutch architectural firms approach this size with the exception of practices such as Bligh Voller Nield (BVN) Architecture, Woods Bagot or Hassell Architecture. In any case, the Coxe questionnaire includes questions about organization and staffing that serve the same role as the inclusion of Mintzbergs organizational structures. Indeed, given the similarity between Winch & Schneiders typology and Coxe's, one might claim that the characteristics of the organization are represented twice in this system.

2.5 Comparison

There is an underlying consistency between all these typologies. All cited typologies to make strong *normative claims* about how firms should be organized. These claims are drawn primarily from management literature, and from the experience of consultants. However there are two problems with all of these typological systems and the strategic advice they embody. The first is a lack of published empirical evidence. The second is that through their generality, these types fail to provide firms with any means of differentiating themselves from their competitors. A firm's closest competitors will all be of the same type.

Table 6: Comparison of Typologies

<table>
<tr><th>Coxe</th><th>Winch & Schneider</th><th>Allinson</th><th>De Bont</th><th>Loonen (Winch & Schneider)</th></tr>
<tr><td>Strong Delivery</td><td>Strong Delivery</td><td>Strong Delivery</td><td>Business</td><td>Strong Delivery</td></tr>
<tr><td rowspan="2">Strong Service</td><td rowspan="2">Strong Experience</td><td>Consultancy*</td><td rowspan="2">Firm</td><td rowspan="2">Strong Experience</td></tr>
<tr><td>Expert Practice**</td></tr>
<tr><td rowspan="2">Strong Idea</td><td>Strong Ideas</td><td rowspan="2">Strong Signature</td><td rowspan="2">Studio</td><td>Strong Ideas</td></tr>
<tr><td>High Ambition***</td><td>High Ambition***</td></tr>
</table>

** Corresponds to Coxe's business centered practice.*

*** Corresponds to Coxe's practice centered business*

**** A smaller start-up version of strong ideas*

As empirical support for their claims the Coxe group published results of a study of 100 firms in the form of two bar graphs showing a significantly higher percentage of firms of satisfaction among firms with a high degree of consistency with their typology than among those with a low degree of consistency. Unfortunately, no definition of *'high'* or *'low'*, and no data were provided concerning the numbers of firms in the high or low groups. Lacking this, the statistical significance of the data cannot be established. A small independent study in the 90's attempted to validate the Coxe Group *Superpositioning theory* (Cheung, 1994), but yielded inconclusive results.. They found a small but statistically significant positive relationship to architectural success using two of three analytical methods, and no significant relationship using the third. They found no significant correlation to financial success (Cheung, 1994).

Further there is evidence that architects do not accept that their own firms fit into the types. Cheung found that many respondents found it difficult to answer the Coxe questionnaire, sometimes feeling that more than one answer was appropriate (Cheung, 1994). In a study of architect's marketing practices in the Netherlands, it was observed that architects were reluctant to identify themselves with a single type (Roberti, 2009; Schaap, Van Der Voordt, & Heintz, 2010). Architects seemed to believe that identification with one type implied a weakness in other areas. Interview respondents claimed to be strong in all three areas: idea, service and delivery. Another TUDelft study showed no correlation between organization type and the architectural typologies (Klein & Volker, 2010). Finding that 90% of the firms responding to the questionnaire were adhocracies. This is perhaps not surprising as the study was dominated by small firms, 60% with 10 or fewer employees and thus within the span of control of a single person. However, it certainly adds to one's scepticism about typology.

The principal advantage of typology is that it provides a simplified view – arguably perceived as *simplistic* by architectural practices. The reluctance of firms to identify themselves as one or another type (ie. without recourse to the Coxe questionnaire) might be a conscious strategic move. At this point firm typology seems to provide an oversimplified or simplistic view of properties that bear on their business strategies. However, the value in typology is that when used well it helps to focus on *"key"* characteristics of their firm and how they interact. Attention is drawn to the relationship between *ownership structure* and *clients*, between *service offer* and *staffing*, between the *goals or ambitions* of the firm and the advancement *opportunities offered to junior staff*. This system offers architects an entry point into understanding their firm in contexts interacting with market and business dynamics.

It would seem therefore that another approach might serve architects better – an approach which left the decision making in the hands of the principle architects, while providing them the tools needed to identify the relevant factors in strategy formation and the relations between them. We propose that the Resource Based View can fill this gap.

3. The resource based view

As an alternative to the typological basis for strategy, we propose to draw on the Resource-Based View (RBV), an approach to strategy that draws attention to a firm's resources and the advantages that the firm can derive from them in expanding, or diversifying into (new) markets. The RBV strategy approach arises out of the work of Edith Penrose on the growth of industrial firms (Penrose, 1959). It holds that a firm is in possession of resources that provide services to the firm and enable it to produce products to be sold in specifically identifiable markets. In short her claim is that firms in possession of unique resources have competitive advantages that they can use to expand. The advantage of RBV for small firms (and architectural firms are almost always small in economic terms) is that it draws attention to the characteristics of the firm itself, rather than to the characteristics of the market (about which a small firm cannot do much). The disadvantage, which prevents us using the more mathematical variations of RBV, is that it is difficult to identify unique resources in a market encompassing a large number of small competitors.

Resources come in a variety of shapes and forms, the may be assets, or capabilities, terminology varies and is sometimes obscure (Fahy, 2000). For our purposes we can designate resources as "asset or input to production (tangible or intangible) that an organization owns, controls, or has access to on a semi-permanent basis," and capabilities as "the ability of an organization to perform a coordinated set of tasks, utilizing organizational resources, for the purpose of achieving a particular end result" (Helfat & Peteraf, 2003). Rather than the unattainable standard of uniqueness, resources and capabilities must fulfil the so called VRIN conditions to be of strategic significance. That is, resources and capabilities must be:

1. Valuable in enabling the firm to exploit opportunities and counter threats.
2. Rare among competitor organizations.
3. Imperfectly imitable.
4. Not easily substitutable. (Barney, 1991; Carter, Clegg, & Kornberger, 2008)

Due to the industrial origins of RBV, resources tend to be defined in terms of the production of mass produced goods to be placed in the market. For architectural firms however, the acquisition of work is as significant as the ability to do it. We therefore propose that resources and capabilities also include those assets that firms may use in acquisition as well as in design. Thus a partial list of resources would include: principles, staff, CAD & BIM (both software and knowledge of how to use it), specialist knowledge (e.g., of building types, specific uses, or relate sciences) portfolio, reputation, client list, etc. Capabilities would include the ability to design, but must also include more specific or specialized design abilities (drawing on specialist knowledge or methods), and abilities to supply additional architectural services such as briefing or construction supervision.

Strategy then becomes a process of examining the firm and it's market and developing a path towards a more desirable fit between the two. Rangone proposes the following steps:

1. Define the company's strategic intent and key performances;
2. Identify the company's resources [including capabilities] influencing key performances;
3. Assess the strategic value of resources, i.e. their ability to create and sustain a long term competitive advantage;
4. Assess the strategic consistency of resources in contributing to the achievement of the strategic intent;
5. Generating strategic options. (Rangone, 1999)

For many architectural firms this may be a difficult confrontation with the generic nature of architectural services. Certainly any given firm can design buildings, they all can – the pertinent question is whether there are any capabilities a firm has that are not shared by most of their competitors. The obvious distinction is in terms of style or signature – but that may not be a distinction that is very important to many clients. Clients may have broad tastes, or they may have other priorities. Likely both. Architects need to develop distinct capabilities and resources that will help them differentiate themselves from their competitors.

4. Conclusion

Current overly simplified for making management decisions aligns with "one size fits all" and does not address the intricate business nature and market demands. The most acute problem facing architects now is acquiring enough work to maintain the firm and allow it realize its goals. Issues such as market segmentation (by building type), service offer (concentrating on schematic design or offering services throughout the building cycle), and differentiation (from the many similar firms in the market) will be the key determinants of firm strategy for the foreseeable future. This will require that firms carefully consider their current resources as well as their ability to develop new resources in light of the particulars of their chosen markets. The RBV view, with its focus on the distinguishing characteristics of individual firms is far better suited to this task than are the typologies discussed above.

The challenges of adopting new technologies and design methods also present real challenges to firms. Architectural firms will need to develop an individualized range of capabilities, specialisms, business awareness and technology adoption aligned with business strategies – moving thus away from a generalist *adhocracy* towards a more considered market positioning and deployment of resources and capabilities. More awareness of image and branding is also to be expected in a profession that highly values *peer critique,* but market demands will present new venues for practicing architects in domains that are not perceived as core to the practice of architecture. Architect practices need to better match their services to the demands of clients, while maintaining their individual character. A portfolio including a number of buildings of a specific type can be changed into a conscious entry into a segmented market with the development of capabilities (such as specialist knowledge of a specific building type and the operations of its occupying institution) derived from experience and aimed specifically at that market. This shift is fundamental to sustain the profession in a highly global competitive market.

Applying other research methods and techniques such as SWOT analyses (Strengths, Weaknesses, Opportunities and Threats) is to add understanding to *quantitative* findings via surveys. Also the use of psychological techniques is proposed such to investigate the decision-making practice principals envision as to their strategies and business sustainability (Fromm, 2004).

Such an approach, while sacrificing the simplicity and normative power of typology will allow firms to examine themselves more thoroughly and to shape themselves uniquely to respond to the goals of the owners, and the characteristics of the staff and portfolio they have acquired over time. Dealing with these characteristics as independent dimensions allows architects to see their firms as occupying unique positions on a number of spectra, and to create a firm that is more highly individuated from its competitors. A more dynamic and responsive diagnosis method is to emerge – providing more realistic and accurate organisation and business maps tailored to specific architecture firms.

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Modelling the flexible behaviour of Singapore contractors in a turbulent business environment

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Abstract

Flexibility has been touted as one of the important requirements for firms to survive and prosper in volatile environments. The aim of this research is to investigate organisational flexibility management in the Singapore construction industry. Under this aim, the specific objectives are to examine the inter-relationships of organisational resources, capabilities and strategies; and ascertain how these relationships affect the development of organisational flexibility. The research was based on a survey design and data were collected via face-to-face interviews with 41 senior executives of large and medium-sized construction firms in Singapore. A structural equation model was developed to examine how firms' learning culture influences their employee skills and behaviour, organisational structure, technological capabilities and business strategies, and in turn, collectively shaping the firms' flexibility potential. The findings show that contractors' learning culture could be categorized along three dimensions, i.e., commitment to learning; shared value and vision; and open-mindedness, which have varying impact on organisational resources, capabilities and strategies, and hence firms' flexibility potential. Employee skills and behaviour, supply chain capabilities and business strategies are found to have highest positive impacts on firms' operational flexibility, tactical flexibility and strategic flexibility, respectively. The findings provide an empirical understanding of what kinds of resources and capabilities construction firms actually accumulate, and how these valuable resources help the firms to respond flexibly to the changes in the business environment within which they operate. It also offers the practitioners in-depth insight into different flexibility building practices and their roles in determining firms' flexibility potential.

Keywords: business strategies, change, operational flexibility, tactical flexibility, strategic flexibility, supply chain capabilities

1. Introduction

The need for construction firms to manage their flexibility is important as a result of the increasing rate of environmental dynamisms in the industry. These include: fluctuating construction demand; increased intensity of competition; changing procurement trend; more stringent clients' performance criteria of construction services; and higher technological need. However, managing organisational flexibility is not easy as flexibility is not general and comprises many dimensions that represent different level of needs for organisations (Lim et al., 2011). Furthermore, the degree of being flexible could be determined by different, but interrelated, organisational resources and competences (Lim et al., 2007). It is thus important for firms to recognise how organisational resources and competences could impact their flexibility potential.

The aim of this study is to investigate organisational flexibility management in construction firms in the Singapore construction industry. The specific objectives are to: examine the inter-relationships of organisational resources, capabilities and strategies; and ascertain how these relationships affect the development of organisational flexibility. These objectives are important in that the findings will inform contractors the kinds of resources and capabilities that could help developing their flexibility potential in response to marketplace uncertainties.

2. Literature Review

2.1 Organisational flexibility

In this study, organisational flexibility is defined as the ability of an organisation to effectively utilize its resources and capabilities to respond or adapt, in a timely and reversible manner to environmental changes, through a continuous learning process, following the definition of Lim et al. (2011). Previous construction-related studies generally regarded flexibility as a uni-dimensional concept (e.g. Lansley et al., 1979). Of these, studies have used it to: (1) assess projects performance (e.g. Walker and Loosemore, 2003); and (2) predict organisational effectiveness (e.g. Handa and Adas, 1996).

However, Lim et al. (2007; 2011) argued that, like studies in manufacturing (e.g. Koste and Malhotra 1999), organisational flexibility in construction should be considered as an integrative multi-dimensional concept that comprises different dimensions of flexibility types. Lim et al. (2011) put forward that only through this way, construction firms could have an in-depth understanding about the nature of flexibility and the means to develop and achieve their superior organisational flexibility. It follows that they have operationalised and categorised the flexibility types into three dimensions. Operational flexibility (Y_{OF}) is operationalised into: modification flexibility; financial flexibility; material flexibility; process flexibility; and spanning flexibility. Tactical flexibility (Y_{TF}) is operationalised by: numerical flexibility; functional flexibility; expansion flexibility; and operation flexibility. Finally, strategic flexibility (Y_{SF}) is operationalised into: volume flexibility; procurement flexibility; product flexibility; and logistic flexibility.

2.2 Organisational resources, capabilities and strategies

The resource-based and organisational learning theories postulate that organisational resources, capabilities and strategies are key sources for organisational competitive (Grant, 1991), and that for organisations to remain competitive, they should engage in a continuous process of learning, unlearning and re-learning so as to develop the right range of resources and capabilities for improved responsive capacity (Sinkula et al., 1997).

The literature review reveals that organisational flexibility may be influenced, to varying degrees, by six organisational features: X1 organisational learning culture (Walker and Loosemore, 2003); X2 organisational structure (Lansley et al., 1979); X3 employee skills and behaviour (Lansley et al., 1979); X4 technological capabilities (Gil et al., 2005); X5 supply chain capabilities (Vickery et al., 1999); and X6 business strategies (Vickery et al., 1999). These six features had been operationalised into 11 constructs that comprised 46 measurement items (see Table 1), following those of Lim et al. (2011).

Lim (2009) reviewed the literature and summarised the relationships among the six features and organisational flexibility. The literature review reveals that organisational learning culture is the key factor driving organisations' features towards affecting their continued existence. Sinkula et al. (1997) explained that a more positive learning orientation will directly result in increased market information generation and dissemination, which in turn, directly influence the degree to which a firm responds to changes in the business environment. This is shared by Teare (1997), who pointed out that organisations should promote a learning environment, characterised by high level of open-mindedness and shared vision and value commitment, so as to enable their employees to effectively communicate and disseminate information for responsive decision making. This further reinforced the findings of Englehardt and Simmons (2002) that organisational structure could shape organisations' business strategies, hence their responsive capacity. Other studies have also identified the key organisational features that could influence an organisation's business strategies. They are: employees' skills and behaviour (e.g. Wright and Snell, 1998); technological capabilities (e.g. Porter, 1985); and supply chain capabilities (e.g. Porter, 1985).

2.3 Gap in knowledge

In construction research, although studies have been done on organisational flexibility, no study has been done to empirically investigate the degree to which individual organisational features collectively affect organisational flexibility. Some studies (e.g. Handa and Adas, 1996) had applied flexibility as an independent variable to predict organisational effectiveness, but did not consider the type of organisational features that contribute to flexibility. For studies that considered flexibility as a dependent variable or desired outcome, many (e.g. Gil et al., 2005) have studied flexibility in project context, rather than construction organisations. Lim et al. (2011) is the closest study done to explore the dimensions of and key determinants of organisational flexibility; but they did not consider the interrelationships of organisational resources and capabilities. It is thus not known how respective resources, capabilities and strategies of construction organisations interrelate and in turn, collectively contribute to different dimensions of organisational flexibility. In this study, fieldwork was undertaken to model these interrelationships toward achieving flexibility, by using a multivariate causal approach (see Figure 1).

3. Research method

A survey design was adopted in this study. Data were collected via face-to-face interviews by using a structured questionnaire, which was pretested before the industry-wide survey was undertaken. The structured questionnaire comprised three main sections, where interviewees were first required to provide general information of their firms, and followed by indicating the extent to which each statement best described their firms' organisational attributes and flexibility potential on a seven-point Likert scale, ranging from 1 (low/ strongly disagree/ seldom/ rarely practised) to 7 (high/ strongly agree/ often/ often practised). The last section gathered demographic characteristics of interviewees. See Table 1 for those measurement items (i.e. statements) included in the questionnaire.

For the survey, a probability sampling design based on the stratified sampling method was adopted whereby interviewees were randomly selected from a stratum of the population. The population comprised general construction firms operating in Singapore's construction industry. This sampling method facilitates the stratification of the Singapore general construction firms into their respective financial groups. The sampling frame comprised building contractors who were continuously registered with the government from 1997 to 2007 in the top three bidding categories (A1 - unlimited, A2 – up to S$65 M (US$1 ≈ S$1.4) and B1 – up to S$30M). All the 91 contractors who survived throughout this 10-year of unprecedented market volatility were selected. It is believed that these contractors may have developed a considerable degree of flexibility and adopted some flexibility practices in response to changes in the industry; thus investigating their organisational attributes could inform practitioners about the key factors driving organisational flexibility.

4. Characteristics of interviewees and their firms

Of the 41 construction firms participated (a response rate of 45%), 17 were from Group A1, and 12 were from Group A2, and 12 were from Group B1 contractors. These contractors had been in operation between 14 and 81 years, with an average of 30 years. Also, about 70% of them had an annual sales volume of ≥ S$50 million (mean = $86.7 million), and had more than 50 supervisory and management staff. With regard to the key informants' characteristics, all interviewees were from senior management (CEO, managing directors, general managers and senior managers) who were key decision- makers in their organisations. They had extensive working experience in the Singapore construction industry, ranging from 15 to 40 years, with an average of 25.4 years. All these suggest that all interviewees are senior and their views are noteworthy. Furthermore, their firms had been in operation for a relatively long time and had enough organisational flexibility attributes to inform this research.

5. Data analysis

The Structural Equation Modelling (SEM) approach, a second-generation of multivariate analysis, was chosen in this study to model the complex relationships among organisational resources, capabilities, strategies towards achieving flexibility. This technique was chosen because it: (1) allows estimation of simultaneous relationships among unobservable predictor and predicted constructs, characterized by their respective block of measurement items (Hair et al., 1998); and (2) enables maximally efficient fit between data and a structural model since both confirmatory factor analysis and path analysis are executed simultaneously in a single structural equation model (Amoroso and Cheney, 1991).

In this study, the Partial Least Square (PLS)-SEM approach was preferred over the covariance-based SEM approach. The justifications are (following Fornell and Bookstein, 1982): (1) PLS-SEM is more oriented towards predictive application and best used for the exploratory nature of this study; and (2) PLS-SEM can analyse a more complex model than covariance-based SEM based on a smaller sample size of 30 -100 and less restrictive data distribution nature.

6. Model development

6.1 Phase 1 –Data preparation

Two tests were conducted, with the use of Statistical Package for Social Sciences (SPSS) software, to detect the presence of common method variance and multi-colinearity problems in the data collected due to the use of the key informant retrospective reporting and subjective data approaches. The Harman's (1967) one-factor test result reveals a 23-factor solution, which accounted for 89.72% of the variance; of which, no single factor accounting for more than 17% of the total variance explained in the data. Next, the Neter et al.'s (1990) variance inflation factors (VIF) test shows that the VIF values for all predictor constructs and the respective mean VIF values are below the suggested threshold level of 10 and 1, respectively. All these indicate that the problems of common method variance and multi-colinearity are not substantial.

6.2 Phase 2 - Measurement models evaluation

Measurement models explain the relationships between constructs and their corresponding measurement items, thus identifying the important constituent of individual constructs. Using the Ringle et al.'s (2005) SmartPLS software, four indices generated were used to establish the reliability and validity of measurement items within their respective constructs. They are: factor loading must be at least 0.45 and significant at $p < 0.05$ (Anderson and Gerbing, 1988); Cronbach's alpha coefficient must be at least 0.70 (Nunnally, 1978); composite reliability score must be at least 0.70 (Hair et al., 1998); and average variance extracted (AVE) value must be at least 0.50 (Fornell and Larcker, 1981).

From Table 1, it can be seen that the 14 constructs and their respective measurement items are reliable and valid, as characterised by their statistical significant factor loadings (0.578 to 0.939), Cronbach’s alpha coefficients (0.703 to 0.906), composite reliability scores (0.818 to 0.926) and average variance extracted scores (0.530 to 0.752). All these provide a great level of confidence in the reliability and validity of the measurement obtained, suggesting that all the constructs involved are both conceptually and empirically distinct from each other.

6.3 Phase 3 – Structural model evaluation

The next step is to evaluate the structural model to determine its explanatory power via path analysis. Table 2 and Figure 1 show the path analysis results of the trimmed PLS-SEM model. Twenty-three out of the proposed 65 paths are found to be redundant, having their respective P_v explained values that range from 0.00% to 1.36%, thus contributing little to the understanding of the variance of organisational flexibility. Five redundant paths, being the highest number, are detected in the risk leadership dimension ($X6_{RLS}$). This is followed by the product leadership ($X6_{PLS}$) and cost leadership ($X6_{CLS}$) dimensions with four and three redundant paths, respectively. It should be noted that the majority of the identified redundant paths are detected in the respective dimensions of firms’ business strategies (X6). In the trimmed PLS-SEM model, all R^2 values of respective constructs have also generally improved and are significant at $p < 0.05$, ranging from 0.189 to 0.614. Also, each of the predictor constructs has accounted for at least 1.5% (following the threshold of Falk and Miller 1982) of the total variance explained in their respective predicted components, indicating that all predictor constructs are informative. All these imply that the trimmed PLS-SEM model has a better explanatory power of organisational flexibility than the untrimmed one.

7. Relationships among firms’ resources, capabilities and strategies

Objective 1 of this study is to examine the inter-relationships among organisational resources, capabilities and strategies towards achieving responsive business operation. There are multiple dependence relationships among respective features are summarised in Figure 1 and Table 2, and these relationships are discussed below.

Table 2 Path coefficient in the Trimmed PLS-SEM model

Proposed paths	Path coefficient (β)	*t*-statistics for β	Proposed paths	Path coefficient (β)	*t*-statistics for β
$X1_O \rightarrow X2$	0.511	3.764***	$X4 \rightarrow X6_{PLS}$	0.171	0.637
$X4 \rightarrow X2$	-0.352	2.673**	$X2 \rightarrow X6_{RLS}$	0.341	2.521**
$X1_{CL} \rightarrow X3$	0.571	5.553***	$X5 \rightarrow X6_{RLS}$	0.431	3.691**
$X1_O \rightarrow X3$	0.112	0.701	$X2 \rightarrow X6_{CIS}$	0.125	0.935
$X1_{CL} \rightarrow X4$	-0.117	0.588	$X3 \rightarrow Y_{OF}$	0.419	3.209**
$X1_{sv} \rightarrow X4$	0.330	1.685*	$X4 \rightarrow Y_{OF}$	0.101	0.578
$X1_O \rightarrow X4$	0.229	1.203	$X5 \rightarrow Y_{OF}$	0.358	2.514**
$X3 \rightarrow X4$	0.220	1.398	$X6_{CLS} \rightarrow Y_{OF}$	0.123	1.167
$X3 \rightarrow X5$	0.339	2.823**	$X6_{RLS} \rightarrow Y_{OF}$	0.044	0.409
$X4 \rightarrow X5$	0.226	1.449	$X6_{PLS} \rightarrow Y_{OF}$	-0.229	2.008*
$X1_{CL} \rightarrow X6_{CLS}$	-0.269	1.926*	$X2 \rightarrow Y_{TF}$	-0.197	0.988
$X1_{sv} \rightarrow X6_{CLS}$	0.250	1.432	$X3 \rightarrow Y_{TF}$	0.158	0.812
$X1_O \rightarrow X6_{CLS}$	-0.204	1.508	$X5 \rightarrow Y_{TF}$	0.415	2.114*
$X5 \rightarrow X6_{CLS}$	0.447	2.503**	$X6_{RLS} \rightarrow Y_{TF}$	0.081	0.323
$X1_{CL} \rightarrow X6_{CIS}$	-0.216	1.347	$X6_{PLS} \rightarrow Y_{TF}$	-0.220	1.563

Proposed paths	Path coefficient (β)	t-statistics for β	Proposed paths	Path coefficient (β)	t-statistics for β
$X1_{sv} \rightarrow X6_{CIS}$	-0.117	0.610	$X3 \rightarrow Y_{SF}$	0.154	0.897
$X1_{O} \rightarrow X6_{CIS}$	0.260	1.514	$X5 \rightarrow Y_{SF}$	-0.095	0.704
$X3 \rightarrow X6_{CIS}$	0.340	2.016*	$X6_{CLS} \rightarrow Y_{SF}$	0.339	1.767*
$X4 \rightarrow X6_{CIS}$	0.491	3.237**	$X6_{RLS} \rightarrow Y_{SF}$	0.324	1.838*
$X1_{CL} \rightarrow X6_{PLS}$	-0.378	2.276*	$X6_{CIS} \rightarrow Y_{SF}$	0.384	2.772**
$X1_{O} \rightarrow X6_{PLS}$	0.384	2.163*	$X6_{PLS} \rightarrow Y_{SF}$	-0.188	1.092

Note: * denotes $p < 0.05$; ** denotes $p < 0.01$
Redundant paths removed due to their low $PV_{explained}$ value of less than 1.5% were not included in this table

7.1 Effect on organisational structure (X2)

Results in Table 2 show that firms' organisational structure (X2) is significantly influenced by their open-mindedness attributes ($X1_O$) and technological capabilities (X4). Of these, $X1_O$ is found to have a positive influence X2, posing a path coefficient (β) of 0.511. This imply that firms with a higher degree of open-mindedness is more likely to have a more flexible organisational structure, as exemplified by their approaches in encouraging employees' involvement in decision-making process (O1) and adapting freely to changes within the environment without much concern to past practices and management practices (O3). However, contractors may need to beware of the possible deficiency in their firms' technological capabilities to supporting their effort to create an open communication platform with flexible access to important information for decision making.

7.2 Effect on employee skill and behaviour (X3)

Table 2 shows that firms' commitment to learning ($X1_{CL}$) is a significant factor driving their employees' skills and behaviour (X3; $\beta = 0.571$). This finding agrees with Sinkula et al. (1997), who found that top management commitment to create an environment that is more instrumental and conducive to learning is an important factor in influencing employees' skills and behaviour. It can be seen from Table 1 that firms' commitment to learning is associated with their efforts to create a working environment, where: (CL1) employees' training and learning are seen as an investment rather than an expense; (CL2) performance mistakes are seen as opportunities for learning and development; and (CL3) employees' learning is the key towards the firm's success in response to changes within the industry. One possible explanation is that employees will feel motivated to work in a team environment (ESB2), which promotes learning and a "no-blame" attitude, and are willing to: (i) share and perform diverse ranges of tasks and responsibilities (ESB4) towards gaining customer satisfaction (ESB5); (ii) be adventurous in exploring new and different alternatives in search of new opportunities or better solutions; and (iii) learn and adapt to different conditions following their firm's strategic direction.

7.3 Effect on supply chain capabilities (X5)

Table 2 shows that employees' skills and behaviour (X3) have positive impact on their firms' supply chain capabilities (X5; $\beta = 0.339$); thus suggesting that superior employees' skills and behaviour are likely to enhance firms' supply chain capabilities. This is especially in a changing competitive business environment where contractors would require their employees to learn and adapt to different business conditions (ESB3) and be customer-oriented (ESB5), working as a synergistic team (ESB2), toward exploring new and better alternatives of materials (SC1) and establishing new supply chain networks for improved organisational abilities in response to changes in their clients' requirement (SC5).

7.4 Effect on business strategies (X6)

The findings in Table 1, revealing the four constructs of business strategies (X6), are in line with Miles and Snow's (1978) generic typology. They are: cost management ($X6_{CLS}$); risk management ($X6_{RLS}$); customer intimacy ($X6_{CIS}$); and product leadership ($X6_{PLS}$).

With regard to $X6_{CLS}$, Table 2 shows that firms' cost management are significantly influenced by their: (i) supply chain capabilities (X4) and (ii) commitment to learning ($X1_{CL}$). Of these, X4 is found to have a positive impact on $X6_{CLS}$ with $\beta = 0.447$. One possible explanation is that a firm's supply chain capabilities in sourcing materials globally (SC1) and offering superior quality of construction services and products (SC2) could improve the firm's abilities to establish an efficient and reliable supply of materials and eliminate unnecessary rework (B3). As a result, these mitigate the impact of unanticipated events on the firm's operation. This agrees with the findings of Treacy and Wiersema (1993) that a firm's supply chain capabilities are directly related to the firm's abilities to: minimise overhead costs; eliminate unnecessary work process; and provide an efficient and reliable supply of products and services. However, it is important for firms to recognise the negative influence of $X1_{CL}$ on $X6_{CLS}$ ($\beta = -0.269$); suggesting that a higher learning orientation may result in ineffective cost management implementation.

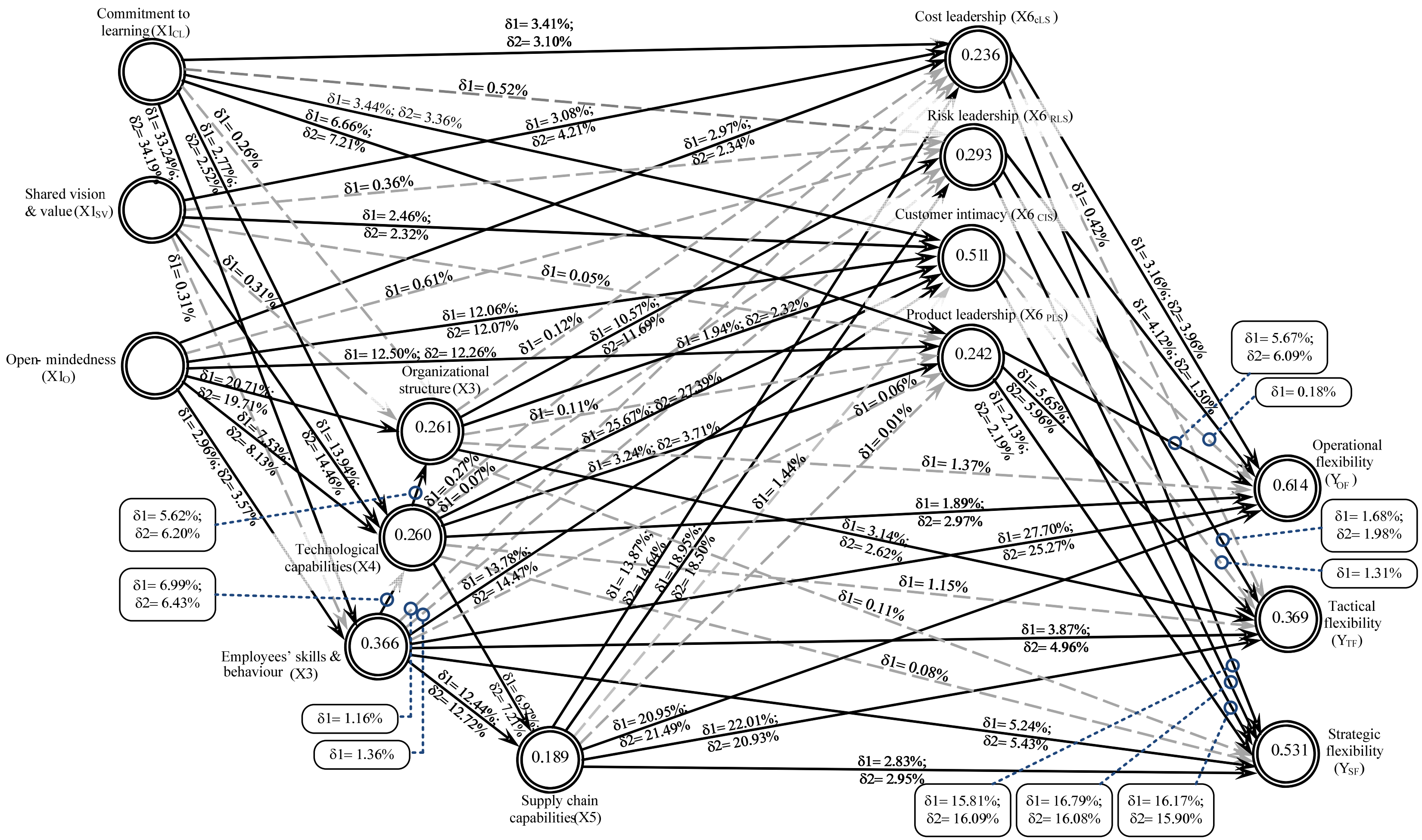
Turning to $X6_{RLS}$, the results in Table 2 show that both supply chain capabilities (X5; $\beta = 0.431$) and organisational structure (X2; $\beta = 0.341$) have positive impacts on firms' risk management initiative. This indicates that supply chain capabilities exert a higher positive impact on a firm's risk leadership initiative than its organisational structure does. Possible explanation on the positive effect of X5 on $X6_{RLS}$ is that when a firm has the abilities to coordinate delivery requirement to meet clients' need (SC5) and attract repeat business from the clients (SC3), they could be customer-focused and thus bids for more projects that are within its capabilities from a targeted group of clients (B5). The interview revealed that that it is important for firms to work with clients with whom they are familiar with in order to minimise the possibility of default in payment by clients, and more importantly, top management should exert control over firms' bidding decision making to avoid any overstretching of resources and capabilities in the project execution phase. Indeed, these findings could help to explain the significant positive relationship between organisations' structure and their risk management initiative.

Table 1 Summary on constructs reliability and validity and weight of measurement items

Constructs (1)	Measurement items (2)	Factor loading (4)	*t*-statistics (5)
Organisational learning culture (X1):			
Commitment to learning (CL)	CL1 - Training and learning are seen as investment rather than expenses	0.855	14.028
α = 0.726; C.R = 0.849; AVE	CL2 - Performance mistakes are seen as opportunities for learning and development	0.716	5.600
= 0.653	CL3 - Ability to learn is the key towards our firm's success in response to changes within the industry	0.845	6.783
Shared vision and value (SV)	SV1 - Encourages brainstorming sessions among employees to share new ideas	0.851	3.901
α= 0.8; C.R = 0.862	SV2 - Provides support to employees to reach organisational goals	0.876	4.226
AVE = 0.613	SV3 - Update employees on the firm's business objectives on a constant basis	0.762	4.215
	SV4 - Involve employees in charting the firm's direction	0.616	2.732
Open-mindedness (O)	O1 - Participative decision making among employees	0.865	9.830
α = 0.829; C.R = 0.899; AVE	O2 - Open communication among employees	0.879	12.587
= 0.749	O3- Ability to change current practices following the industry trend	0.853	8.956
Organisational structure (X2)	OS1 - A flexible work procedure	0.869	5.818
α= 0.833; C.R = 0.901; AVE	OS2 - A more decentralized decision making process	0.873	6.378
= 0.752	OS3 - An open communication channel with flexible access to important information for decision making	0.860	5.472
Employee skills and	ESB1 - Adopt an open mindset to all alternatives	0.694	6.645
behaviour (X3)	ESB2 - Work in a team environment	0.845	8.616
α= 0.833; C.R = 0.878; AVE	ESB3 - Learn and adapt to different business conditions	0.778	7.470
= 0.547	ESB4 - Perform a diverse range of tasks and responsibilities	0.694	5.713
	ESB5 - Gain customer satisfaction	0.696	6.867
	ESB6 - Work independently	0.720	5.714
Technological capabilities	TC1 - Communicate and share information among supply chain parties regardless of geographic dispersion	0.869	23.472
(X4)	TC2 - Communicate and share information among all decision makers and employees regardless of geographic dispersion	0.861	15.967
α = 0.906; C.R = 0.926; AVE = 0.641	TC3 - Retrieve information from the company database in a timely manner regardless of geographic dispersion	0.770	9.076
	TC4 - Disseminate up-to-date and accurate information and link similar information to decision makers	0.838	10.366
	TC5 - Adopt different construction process technologies to satisfy clients' requirements	0.801	8.785
	TC6 - Apply different process technology software to improve firm's operational process	0.735	6.153
	TC7 - Lead in process technology innovation to gain competitive advantage	0.720	9.648
Supply chain capabilities	SC1 - Procure materials on a global basis	0.810	12.209
(X5)	SC2 - Improve the quality of construction services and products	0.763	8.757

Constructs (1)	Measurement items (2)	Factor loading (4)	*t*-statistics (5)
α = 0.788; C.R = 0.867	SC3 - Attract repeat business from clients	0.634	4.719
AVE = 0.568	SC4 - Improve construction delivery speed	0.771	6.804
	SC5 - Coordinate delivery requirement to meet clients' need on a global basis	0.778	12.714
Business strategies (X6):			
Cost management (CLS)	B1 - Implement stricter financial management on company cash flow	0.722	3.637
α = 0.737; C.R = 0.852;	B2 - Set limits on project size	0.800	5.362
AVE = 0.591	B3 - Implement stricter site management to reduce material wastage	0.855	6.733
	B4 - Implement stricter procurement management	0.689	4.777
Risk management (RLS)	B5 - Bid for more projects that are within the firm's capabilities	0.815	6.123
α = 0.733; C.R = 0.852;	B6 - Create uncommitted financial resources	0.796	4.375
AVE = 0.657	B7 - Enter into forward contracts with suppliers & subcontractors	0.820	4.488
Product leadership (PLS)	B8 - Invest on assets that have high liquidity value	0.826	2.761
α = 0.723; C.R = 0.845;	B9 - Invest into R & D to further explore business opportunities	0.770	2.877
AVE = 0.645	B10 - Investing surplus funds into financial investments and property development	0.813	4.164
Customer intimacy (CIS)	B11 - Form joint-venture with other contractors to serve a group of targeted clients	0.665	5.046
α = 0.761; C.R = 0.846;	B12 - Form partnership with clients	0.874	23.079
AVE = 0.582	B13 - Diversify into different construction business	0.702	5.841
	B14 - Follow clients abroad	0.793	8.272
Organisational flexibility (Y):			
Operational flexibility (OF)	F1 - Modify your firm's operational structure	0.788	5.832
α = 0.825; C.R = 0.880;	F2 - Integrate, construct and reshape your firm's financial resources	0.707	3.245
AVE = 0.594	F3 - Construct facilities using different construction methods and materials	0.752	11.104
	F4 - Make decisions on non-routine and significant events which cannot be anticipated in advance	0.819	9.341
	F5 - Integrate your internal functions with external firms in providing value-added services to clients	0.784	6.805
Tactical flexibility (TF)	F6 - Change the number of employees in your business operation	0.725	3.520
α = 0.783;C.R = 0.854;	F7 - Employees' ability to handle multiple responsibilities	0.757	5.432
AVE = 0.594	F8 - Add and expand your business capacity efficiently	0.806	6.156
	F9 - Adopt a range of alternative logistics supports to operations	0.792	6.308
Strategic flexibility (SF)	F10 - Operate effectively and profitably in different market conditions	0.675	4.397
α = 0.703; C.R = 0.818;	F11 - Exploit a range of procurement options effectively	0.824	9.209
AVE = 0.530	F12 - Provide a range of construction services	0.731	6.269
	F13 - Respond to changes in delivery schedule due to unpredictable changes in clients' requirements	0.672	3.949

Legend: α denotes Cronbrach's Alpha Coefficient; C.R denotes composite reliability; AVE denotes Average Variance Extracted; and CFA denotes confirmatory factor analysis.



Legend: = Redundant path removed; δ1 = $PV_{explained}$ (%) for original PLS Model; δ2 = $PV_{explained}$ (%) for trimmed PLS Model

Figure 1 Structural model for organisational flexibility

Next, it is found that employees' skills and behaviour (X3) and technological capabilities (X4) are the two key positive factors driving firms' customer intimacy initiative ($X6_{CIS}$) (see Table 2). Of these, X4 (β = 0.491)has a greater impact than X3 (0.340) on a firm's customer intimacy endeavour. The findings are consistent with those of Crocitto and Youssef (2003) that appropriate application of information and communication technologies can potentially enhance a firm's competitiveness via establishing an effective and responsive network to facilitate information processing and communication among supply chain members. This is especially true in the project-oriented and information intensive environment of the construction industry where highly responsive contacts among their supply chain members is the key toward on-time delivery of products and services. However, to reinforce their customer intimacy initiative, firms should also recognise the skills and behaviour of their employees since they are the key resource towards gaining clients' loyalty, and thus shaping firms' customer intimacy endeavour (Treacy and Wiersema, 1993)

In this study, firms' product leadership initiative ($X6_{PLS}$) is found to be significantly influenced by their open-mindedness ($X1_O$; β = 0.384) and commitment to learning ($X1_{CL}$; β = -0.378) (see Table 2). This suggests that contractors with positive attitude of open-mindedness are likely to possess superior capacity in pursuing their product leadership strategies. However, to be effective, firms should be mindful in creating a "balanced" learning environment that promotes their product leadership initiatives ($X6_{PLS}$). It is because higher learning commitment may result in less effective product leadership initiatives considering the possible "careless" attitude of employee in a "no-blame" and "unchallenged" working environment, as characterised by the negative influence of $X1_{CL}$ on $X6_{PLS}$.

8. Implications on organisational flexibility management

Objective 2 is to ascertain how these relationships among organisational resources, capabilities and strategies affect the development of organisational flexibility. Their implications on the flexibility dimensions are discussed below.

Table 2 shows that firms' operational flexibility (Y_{OF}) is significantly influenced by their: (1) employees' skills and behaviour (X3; β = 0.419); (2) supply chain capabilities (X5; β = 0.358); and (3) product leadership initiative ($X6_{PLS}$; β = -0.229). Of these, X3 are found to have a larger positive influence on Y_{OF} than X5 does. This phenomenon can be partially explained by the triangular relationships among X3, X5 and Y_{OF}, where employees' skills and behaviour are the key enablers between organisational capabilities and performance. In this case, the skill and behaviour of employees could initially influence a firm's supply chain capabilities (X5), and in turn, both these features shape the firm's operational flexibility. This finding agrees with Cameron and Green (2004), who pointed out that employees' willingness to learn new skills and change is at the heart of everything that is achievable within an organisation - when employees are unwilling to learn or adapt, their resistance may considerably affect firms' endeavours to improve their responsive capabilities. Therefore, contractors may need to continually monitor their organisational culture so as to foster a "balanced" and "productive" learning environment for better realisation of behavioural change and skill improvement of their employees. This is only upon gaining their behavioural commitment and improving their skills, firms could then have superior supply chain capabilities, which lead to enhanced operational responsiveness.

To strengthen their responsiveness, firms should be disciplined and mindful in their product leadership initiative ($X6_{PLS}$); as firms with wide business portfolios are likely to incur major investment (i.e., sunk cost) in their product development, and therefore become less operationally flexible in the face of any environmental turbulence. This agrees with Drucker (1980), who pointed out that firms should focus on their fundamental business and stick to the basics rather than venture into unfamiliar business areas. It is therefore important for firms to recognise the risks involved in new product development, and be aggressive in a disciplined manner when developing new business ventures. This may further help to explain the positive influence of risk management ($X6_{RLS}$) on a firm's strategic flexibility (Y_{SF}) potential.

Like operational flexibility (Y_{OF}), the results show that firms' tactical flexibility (Y_{TF}) is also positively influenced by their supply chain capabilities (X5; $\beta = 0.415$). This suggests that, to have superior operational and tactical flexibility potential, firms may need to hone their supply chain capabilities (X5) by continuously monitoring their employees' skills and behaviour (X3). This finding agrees with Kale and Arditi (2001), who found that having high quality relationship with subcontractors is positively associated with contractors' economic performance.

With regard to strategic flexibility (Y_{SF}), three out of the four dimensions of business strategies are found to have positive influences on a firm's strategic flexibility. In the order of importance, they are: (1) customer intimacy initiative ($X6_{CIS}$; $\beta = 0.384$); (2) cost leadership initiative ($X6_{CLS}$; $\beta = 0.339$); and (3) risk leadership initiative ($X6_{RLS}$; $\beta = 0.324$). These imply that contractors' past quality relationship with clients and established reputation play a leading role in dictating their strategic flexibility. This is especially applicable in the private sector contracting where the established relationships and firm reputation could often present contractors with contracting opportunities to bid for projects when economic times are bad. Therefore, it is vital for construction firms to proactively and continuously engage themselves in relationship and reputation management regardless of whether times are good or bad. To achieve a high level of customer intimacy, contractors would need to develop their core competences such as employees' skills and behaviour (X3) and technological capabilities (X4).

Complementing their customer intimacy strategies ($X6_{CIS}$), contractors should also need to assume a more active role in their cost and risk management in order to remain strategically flexible in a changing business environment (i.e. $X6_{CLS} + X6_{RLS} \rightarrow Y_{SF}$). To achieve superior strategic flexibility, they should manage risk ($X6_{RLS}$) effectively by bidding rationally for projects and expanding their business within their available resources and capabilities, and at the same time, establishing, monitoring and reviewing their cost control protocols regularly.

9. Conclusion

This study investigated organisational flexibility management of Singapore construction firms. Data were collected via face-to-face interviews with senior management of construction firms, which had survived the unprecedented long period of volatile business environment from 1997 to 2007.

This study contributes to knowledge in construction business management by modelling the interrelationships of firms' resources, capabilities and strategies towards achieving organisational flexibility. It provides empirical evidence that organisational flexibility is a multi-dimensional concept comprising: (i) operational flexibility; (ii) tactical flexibility; and (iii) strategic flexibility. Each of these dimensions could be influenced by distinct integration of firms' resources, capabilities and strategies. It thus offers a new plausible explanation for the factors influencing organisational flexibility management in construction. Lastly, it is acknowledged that, owing to the exploratory nature of this study and its small sample size used, the results are not definitive but indicative of a perceived trend. Also, this study acknowledged that there may be a problem of common method variance due to the use of the key informant retrospective reporting and subjective data approaches. Future studies could adopt the following methods to overcome this limitation: (i) the complementary use of more objective data; (ii) the use of multiple informants that involves the cross-checking of reported information; and (iii) the use of the multitrait-multimethod matrix technique that involves application of different data collection methods in collecting a similar set of data.

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Supply Chain Management in Construction: Three developments in search of a theory

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Abstract

This research engages with recent calls within the supply chain management community to advance conceptual theory development. Theory development arguably defines a scientific discipline, provides operational legitimacy and formulates systematic frameworks for further analysis and critical evaluation. Over the past two decades supply chain management in a construction context has largely borrowed ideas and concepts from other industries, most notability the automotive and manufacturing sectors. Whilst this may be convenient for casual comparison, others argue that close assimilation with other industries only serves to confuse and confound the conceptual comprehension of supply chain management in a construction context.

Three areas of development arguably dominate the supply chain management debate; conceptual immaturity, post-positivist models of research and editorial gatekeepers. First, given the lack of conceptual maturity, especially within supply chain management and construction it is logical to explore and exploit established academic disciplines such as economics and management. However, inter-disciplinary synthesis with supply chain management and construction requires careful and incremental refinement to accommodate inherent and contextual limitations. Secondly, to engage meaningfully with conceptual theory development requires alternative methodological models of enquiry. In construction management literature the positivist models of hypothesis testing need to be complemented with post-positivist iterative models of research. A methodological correction in construction management research would arguably inform and stimulate critical debate. Thirdly, searching for a theory requires encouragement and sponsorship. In this respect, academic journals, their editorial boards and reviewers all have a key role to play. Without the support of enthusiastic journals and reviewers sympathetic to largely qualitative approaches, the search for a theory of supply chain management in a construction context is likely to remain vague.

Despite considerable construction industry interest, the theoretical understanding of supply chain management continues to reflect concepts and practices rooted elsewhere. This paper identifies and discusses three key developments in search of a theory of supply chain management in a construction context. Individually, the developments represent important milestones in theory building; in concert these developments would arguably spark an intellectual curiosity that would further advance the conceptual development of supply chain management and construction.

Keywords: Supply Chain Management, Theory Building, Construction Industry

1. Introduction

"*Theory defines a scientific discipline*" (Carter, 2011 p.3). In addition, theory formulates systematic frameworks (Whetten, 1989), informs public policy (Koskela, 2008) and provides operational legitimacy (Pinder and Bourgeois, 1982) for further analysis, critical evaluation and theory development. Recent calls from the supply chain management community have challenged academics and practitioners to proactively engage with theory building approaches (Choi and Wacker, 2011). In contrast to well-established and refined domains of study such as economics or management, it is argued that supply chain management is devoid of a conceptual foundation (Carter, 2011). According to Carter (2011), the lack of supply chain management theory building subsequently stifles maturity, accepts mediocrity and simply sponsors compliance with already established policy and procedure. The net outcome is preservation of the status quo.

To challenge established tenets of supply chain management with a critical appraisal is arguably a reflection of discipline maturity and progressive scientific outlook. For example, internationally recognized journals in economics and management have on a number of occasions dedicated special issues and editorial forums to the notion of theory building (Van de Van, 1989, Rindova, 2008). The supply chain management community readily acknowledge this 'conceptual gap' and importance in developing uniqueness, fecundity and cognitive integration (Wacker, 1998). Theory building in the built environment has also received recent attention (Koskela, 2008), however connecting theory building with supply chain management and the construction industry arguably remains underdeveloped, marginalized, patchy and without vital sponsorship.

Over the past two decades supply chain management in construction has largely borrowed supply chain management theory and practice from other industries, most notably the automotive, retail and manufacturing sectors (Briscoe and Dainty, 2005). Whilst this may be convenient for casual comparison, others argue that close assimilation with other industries only serve to confuse and confound the conceptual comprehension of the construction sector (Groak, 1994, Fernandez-Solis, 2008). Notwithstanding repeated arguments for a contextually sensitive response (Fernie et al., 2003), supply chain management practices witnessed elsewhere continue to be wholeheartedly embraced. Given recent calls within the supply chain management community to advance conceptual theory development, the construction sector with its fragmented structure, discontinuous work patterns, complex power relations, history and routine is arguably well-placed to make a critical contribution to the ensuing debate.

This research paper echoes recent calls for supply chain management theory building. Those within the construction sector similarly have a role to play; especially given that supply chain management theory building in construction remains sparse and uneven. This is manifest in the language, metaphors and 'taken for granted' institutional assumptions of many 'borrowed' and rehashed theories. Part of the difficulty for construction as 'compulsive borrowers' from many other eclectic disciplines is that very often the utility of the theories adopted is strictly limited to the settings where its institutional assumptions are in force. For example, the discourse of supply chain management in manufacturing is frequently used to endorse and diffuse supply chain management 'best practice' in construction (Rimmer, 2009) despite the obvious differences. Contrary to the endemic practice of theory borrowing and testing, the ambition of this paper is to explore developments that may advance theory building in the field of supply chain management and construction. Three developments arguably dominate the supply chain management theory building debate; conceptual immaturity, post-positivist models of research and editorial gatekeepers (Carter, 2011).

The paper is organised as follows. Following the introduction, the rationale for theory building is explored and developed. The next section connects the notion of theory building with supply chain management and construction. Within the discussion, three key areas of research development come under critical scrutiny namely; conceptual immaturity, post-positivist models of research and editorial gatekeepers. It is recommended that a construction contribution to recent calls for theory building in supply chain management will provide an alternative and discerning perspective to the mainstream management debate.

2. Theory Building

Despite considerable academic interest and study, a universal definition of the term 'theory' remains shrouded in a fog of conceptual dissonance (Corley and Gioia, 2011). Given the absence of a definitive meaning of 'theory', it remains "*difficult to separate what is theory from what isn't, especially if theory development starts with guesses and speculations and ends with explanations and models*" (Weick, 1995). In an attempt to develop the theory of conceptual development, Corley and Gioia (2011 p.12) succinctly characterize theory as "*a statement of concepts and their interrelationships that show how and/or why a phenomenon occurs*". The key use of 'how and/or why' is further complemented by Whetten's (1989) assertion that addressing research questions of how, why, where, what, when and who form the foundation for theory building.

In contrast, Sutton and Straw (1995) offer an unconventional approach to clarify what constitutes theory building by stating clearly what theory is not, namely; references, data, constructs or diagrams. Making sense of theory and theory building simply as an outcome or product would ultimately support Sutton and Straw's standpoint (Weick, 1995). However, contrary to the notion of theory building as a product, according to Weick (1995) theory building is a process and may justifiably rely on references, data, constructs and diagrams as staging posts in conceptual maturity. Despite the divergent viewpoints on what theory is or is not, four building blocks of 'good' theory; clarity of expression , distinct discipline, relationships and prophecy are more widely acknowledged (Wacker, 1998).

A general consensus relating to the essential building blocks of good theory is helpful, however precisely what finally differentiates 'good' theory from 'bad' theory remains highly contentious. According to Lewin (1943 p.113) "*there is nothing more practical than good theory*". Alternatively, Ketchen and Hult (2011 p.13) suggest good theory simply presents "*ideas that contradict pre-existing notions and offer well-articulated alternatives in their place, spark others' intellectual curiosity and inspire people to conduct further research*". Somewhat contrary to empirical forms of research protocol, a 'well-articulated alternative' does not necessarily require logical substantiation; the goal of good theory is to generate interest, stimulate dialogue and excite (Skilton, 2011). Expressed simply, "*good theory is a plausible theory*" (Weick, 1989 p.517)

In response for greater conceptual clarity especially within the discipline of social science, Glaser and Strauss (1967) pioneered a process to theory building called 'grounded theory methodology'. The methodological outlook challenged mainstream positivist models of enquiry by favouring conceptual frameworks of cross-examination and inductive analysis (Bryant and Charmaz, 2010a). The resultant grounded theory methodology of iteration and 'self' subsequently raises many fundamental questions and is not without criticism. The role and 'objectivity' of the researcher and the use and 'clarity' of the data is frequently the subject of epistemological debate and methodological tension (Astley, 1984).

The process of theory building and accompanying research methodologies such as grounded theory therefore challenge many preconceived notions connected with mainstream research strategies. The methodological discussion is arguably not about right or wrong, the debate is essentially addressing the notion of 'fit for purpose'. For example, scientific rigour is frequently judged in terms of three central axioms namely; objectivity, validity and pragmatism (Astley, 1984). For theory testing as opposed to theory building this approach is indeed fit for purpose.

However, it is repeatedly contested that the success of theory building cannot be measured simply in terms of conventional scientific rigour. Given the largely aesthetic ambition to postulate and spark an intellectual curiosity within the scientific community, 'hard' evidence favoured by the traditional custodians of scientific rigour is arguably inappropriate. On the contrary, 'soft' validation such as 'practical' (Lewin, 1943), 'plausible' (Weick, 1989) and 'that's interesting' (Davis, 1971) better reflect the abstractionist qualities of good theory building. A successful conceptual article "*has to excite these essentially aesthetic sensibilities in the author or in other scholars to such an extent that they set about the process of falsification, and thereby extend the life of the theory*" (Skilton, 2011 p.23). In other words if the theory makes sense, theory testing will follow.

3. Supply Chain Management and Construction

Supply chain management in construction continues to grow in popularity (O'Brien et al., 2009). The volume and array of publications are testimony to the increasing importance of supply chain management as applied to the construction industry (Meng et al., 2011). Over the past three years numerous books on the topic have been published (Pryke, 2009, O'Brien et al., 2009, Benton and McHenry, 2010) and in the second half of 2010 two academic journals in the field of supply chain management dedicated special issues to supply chain management in the construction industry (Ellegaard et al., 2010, Segerstedt and Olofsson, 2010). In addition, 2011 also witnessed the inaugural publication of the International Journal of Construction Supply Chain Management.

A review of supply chain management publications disclose a wide range of academic and industry interest, however the debate largely focuses on the utility, applicability and performance of supply chain management and construction practice. There are compelling reasons for the implementation of supply chain management in construction. For example, given the significant levels of sub-contracting, the construction sector arguably epitomises key characteristics likely to benefit from the principles of supply chain management. Advocates of supply chain management are also keen to highlight significant commercial opportunities for greater integration, collaboration, trust, organizational learning and ultimately economic advantage.

However, within construction there are also enduring circumstances that arguably inhibit the development and diffusion of the supply chain concept (Briscoe and Dainty, 2005). It is often argued that supply chain management as practiced in construction is a laggard in comparison with practice witnessed elsewhere (Lonngren et al., 2010). However, to allude that the characteristics of the construction sector are comparable to the automotive industry, aerospace or retail is unjust (Green et al., 2005). As a result, the lack of contextual sensitivity "*leaves open the possibility of implied identity*" (Pinder and Bourgeois, 1982 p.642) and misleading generalizations.

Reliance in much of the work has been founded on an assumption that supply chain management practice in other sectors is transferable to construction. Indeed, it is the practice of supply chain management that provides the focus of attention for industry and academia alike. This assumption has largely squeezed out explorations and substantiation of supply chain management theory and how such theory connects with and can be used to interpret or reform and possibly even reflect and/or reinforce practice within organisations in the construction sector. Connecting and building theory of supply chain management with associated practice(s) of the construction industry would undoubtedly inform the wider academic and industry supply chain management forum.

4. Discussion

Three areas of development arguably dominate the supply chain management and construction debate; conceptual immaturity, post-positivist models of research and editorial gatekeepers. First, conceptual immaturity relates to the lack of indigenous theoretical development. Second, post-positivist models of research refer to alternative research methodologies and finally, editorial gatekeepers highlight the key role academic journals play in sponsoring theory building development. The list of three developments in search of a theory is intended to be only suggestive, not definitive nor exhaustive.

4.1 Conceptual Immaturity

Construction is a 'compulsive borrower' of theory, including supply chain management. Given the institutional pressure to comply with 'construction best practice', construction organizations seek supply chain legitimacy in a number of alternative ways. First, construction organizations may adopt the symbols and ceremony of established supply chain practice. Second, under duress to conform organizations may imitate industry competitors to reinforce their supply chain credentials. Theorizing is not dissimilar. By borrowing the 'symbols' and 'ceremony' of established theory, the legitimacy and expediency of proposed 'new' theory is customarily assured (Pinder and Bourgeois, 1982). Paradoxically, the commercial pressure to borrow both 'the theory' and 'the language' of supply chain management especially as observed in manufacturing (Rimmer, 2009) and expedite to construction compromises the development of both ‘local’ theory building and research vocabulary.

Language is an significant product of research (Astley, 1984) and is fundamental to successful diffusion of discourse regardless of scientific domain. Often slight variations in linguistic phrasing appear non-consequential. However contrary to the notion of light-hearted semantics, the repeated use of metaphors is often skilfully calculated to seduce, resonate and frequently strengthen an often politically infused agenda with a carefully targeted audience. This is not a wholesale criticism of pressure groups, political or otherwise with a vested interest in a particular outcome. It is simply recognition that research language and especially the use of metaphor is a powerful and persuasive tool for the diffusion of supply chain management theory and practice.

The use of metaphors in construction management discourse has not gone unnoticed (Green, 2011). For some, metaphors greatly assist in bridging theory with practice (Prange, 1999). According to Prange (1999) the complexity of social action and interaction can be linguistically framed in figures of speech that will enhance the cognitive development and dissemination of a theory. However, the use of metaphors as a “*way of thinking*” (Prange, 1999 p.37) is also strongly contested. According to Pinder and Bourgeois (1982), repeated use of tropes, undetected or unchallenged will ultimately hamper theory building and severely hinder scientific progress.

The language of supply chain management and construction is not free from ambiguity. In construction the following expressions, ‘supply chain management in construction’ and ‘construction supply chain management’ are often used interchangeably to discuss concepts of supply chain management theory and practice. Given the subtle nuances, conflating the two expressions is unlikely at present to cause confusion or misunderstanding. However, it may also be argued that linguistic precision and framing is fundamental to the formation of a robust and coherent theory of supply chain management as applied to a construction setting.

Critically, it may be ascertained that supply chain management in construction is not synonymous with construction supply chain management. The former relates to the theory of supply chain management, founded largely upon principles of economics, law, organization and management studies (Carter, 2011). Writing about supply chain management in construction represents the study of supply chain management theory (as currently understood) applied to the construction arena. The latter, construction supply chain management relates specifically to the policies, procedures and practices of construction. Consequently, writing about construction supply chain management represents the study of construction (as currently understood) and the construction industry’s unique translation and construal of supply chain management theory and practice. The lack of; clarity in expression, distinct discipline, relationships and prophecy (see Wacker, 1998) simply discloses key dimensions of conceptual immaturity.

4.2 Post-Positivist Models of Research

In research "*the validity or 'truth' in findings is paramount*" (Muncey, 2010 p.100). Typically, scientific validation involves a process of hypothesising and testing using deductive research methodologies. However, contrary to the dominant deductive research strategies (Orton, 1997) favoured in construction, alternative inductive methodologies "*start from the position that our knowledge of reality…is a social construction by human actors and that this applies equally to researchers*" (Kaufmann and Whu, 2011 p.64). According to Fawcett and Waller (2011 p.3), "*switching from deduction to induction may bring new light and perspective to common problems and widely accepted theories*". Given that theorists often "*write trivial theories because their process of theory construction in hemmed in by methodological strictures that favour validation rather than usefulness*" (Lindblom, 1987 p.512), a methodological correction in the study of supply chain management and construction would arguably stimulate critical debate and newfound research opportunities.

However, to suggest positive discrimination to advance theory building in construction is likely to provoke deep-seated tensions between advocates of logical positivist research strategies and supporters of reflexive, post-positivist research methodologies (Wing et al., 1998). Thomas and James (2006) caution against the unscientific practice of squeezing a reluctant post-positivist narrative into a positivist canon of verification. However, despite the often entrenched position of academics and researchers alike it is arguably justifiable to have very clear but separate expectations of both theoretical paradigms.

One of the first major methodological attempts at analysing and explaining socially constructed processes in explicit theoretical and empirical statements was grounded theory (Wertz et al., 2011). Grounded theory is described by Fellows and Liu (2003) as the discovery of theory systematically acquired via social inquiry 'grounded' in data collection. Although grounded theory is only one of many theory building methodologies, a summation of grounded theory arguably reflects the typical tensions and disquiet evoked within the research community (Bryant and Charmaz, 2010b).

Reservations of grounded theory's epistemological integrity dwell primarily the iterative-inductive approach to generating so-called 'scientific' data. Often judged as largely intuitive by research conformists, they contest grounded theory methodology deviates beyond acceptable boundaries of objectivity, validity, and pragmatism (Astley, 1984). Notwithstanding repeated criticism, over the years grounded theory has established a positive reputation especially within the social science disciplines of education and health (Mills et al., 2006). Proponents argue if carefully managed with a research discipline and rigour characteristic of the traditional positivist doctrine, grounded research and by extension post-positivist, reflexive research strategies may illuminate a highly contextualized interpretation (Fawcett and Waller, 2011) currently beyond the scope of logical positivist methodologies. In addition to clearly defining the scope and expectations of different research strategies, a 'good' theory requires access to an audience.

4.3 Editorial Gatekeepers

Searching for a theory not only requires participation, encouragement and a range of alternative research methodologies, crucially it also requires sponsorship. In this respect, academic journals, their editorial boards and reviewers all have a key role to play. As gatekeepers of academic rigour and standards, they have the power of censorship (Holt, 2003). Consequently, without the support of enthusiastic journals and reviewers sympathetic to theory building and largely inductive research methodologies, the search for a developed theory of supply chain management in construction is likely to remain vague and arguably undervalued. Given the methodological tensions, the challenge for potential sponsors of theory building is to uphold academic rigour on the one hand and simultaneously encourage inventiveness on the other.

Academic journals justifiably set stringent criteria for publication. The establishment and compliance of both academic rigour and relevance is core to a journals reputation and standing within the research community. However interpretation of rigour and relevance is undoubtedly influenced by the personal beliefs and bias held by individual reviewers, who act collectively on behalf of the journal as academic gatekeepers of standards and ethics (Ketchen and Hult, 2011). Conversely, in an increasingly post modernist society "*it is surely incumbent on the gatekeepers of research to share perspectives on a variety of research methodologies, styles and representation, and evaluate criteria, rather than privilege the authority of dominant viewpoints*" (Holt, 2003 p.26). As a result, editorial guidance has a central role to play. As potential 'sponsors' of theory building', special issues in particular represent an ideal medium for academic journals and suitably skilled reviewers to encourage participation, share perspectives and ultimately craft new theory.

A review of established construction management related journals disclose limited interest in the notion of theory building. With the exception of a special issue of Building Research Information (Koskela, 2008), theory building in the built environment remains marginalized. Without progressive editorial sponsorship and sympathetic reviewers, the development and diffusion of supply chain management in a construction context will remain hampered and ultimately devoid of a robust and coherent intellectual foundation.

5. Recommendations and Conclusion

Despite growing academic and construction industry interest (O'Brien et al., 2009), the theoretical understanding and practice of supply chain management continues to reflect concepts and case studies rooted elsewhere. The borrowing of supply chain management theory and language is arguably an instrumentally driven response to resultant environmental challenges. It is not beyond doubt that adopting the language and metaphor of alternative theories provide academic legitimacy and expediency (Pinder and Bourgeois, 1982). Both qualities are valuable endorsements in an increasingly competitive research marketplace. However, compulsive borrowing of theories complete with language is arguably hampering the maturation of supply chain management theory (Carter, 2011) as applied to the construction industry.

Supply chain management in a construction context is repeatedly expected to mirror performance levels observed in other industries, most notably manufacturing. However, industry efforts to replicate the efficiency and effectiveness of manufacturing, not just in terms of supply chain management practice but also in more general terms "*continue to generate significant differences between expectations and results*" (Fernandez-Solis, 2008 p.43). Given the almost systemic disappointment in supply chain performance, endorsement of theory building in construction management research may help 'plug' the conceptual gap between theories borrowed and the daily realities of construction practice.

Shifting the academic gaze away from theory testing towards theory building requires both strong leadership and an adjustment of research values. To encourage theory building contributions it may therefore be appropriate to purposefully disaggregate theory from practice. This avant-garde approach directly challenges the 'taken for granted' evolution of theory development to industry practice as a core ambition of scientific research. However, temporarily decoupling theory building from the shackles of a research orthodoxy rooted in 'hard facts' as opposed to searching for scientific truths, may promote theory building as a valuable and worthwhile scientific contribution in its own right (Astley, 1984). If the theory is interesting, plausible and sparks an intellectual curiosity, verification will follow and eventually so will practice.

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Social Capital and Construction Project Management: a Vignette and Theoretical Framework

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Abstract

Extant discourse of organizational social capital has been concentrated on permanent organizational settings. The basic tenet of the concept of social capital is that the social relations of actors within social sphere can be used to facilitate actions among the focal actors and those others that are directly or indirectly associated with the focal actors. This utilitarian notion of the concept should transcend organizational settings. In this respect, although paradoxical, with the construction project peculiarities of fragmentation, the lack of a central authority, transient organizing, interdependence and the resultant need for integration, and relative closure, social capital may be more relevant to project organizing. However, given that social capital represents the primordial feature of social activities among actors and its utility is contingent upon active use and engagement, the effects of social capital on project organizing is likely to be channeled through project organizational processes. We examined this proposition with the use of a vignette derived from case study of a building construction project in Hong Kong. Through the vignette, we demonstrate the applicability of the concept in construction project settings in relation to the proposition. Based on the findings, we put forth a theoretical framework of the social embeddedness approach to project organizing.

Keywords: Social capital; Construction project organization; Relational paradigm

1. Introduction

A project comprises of a collection of human operators that are engaged in a nexus of activity through which the operators could collaborate to achieve their objectives. Because project participants have to interact among themselves in the conduct of these activities, a project can also be viewed as a sequence of events the dynamics of which are contingent upon the quality and characteristics of the relationships and interactions of those participants (Jones and Lichtenstein, 2008). Here, the project affairs are highly influenced by both the structure of the relations and the collective rules of collaboration. Project organizations, viewed this way, are characterized by the network of relationships that shape the network activities, the evolution of these activities, and the relationships among the participants (Doreian, 2002; Kenis and Knoke, 2002).

The collective features of the social relations of participants within the social sphere (e.g. quality of relations, structural features of ties) can be used to facilitate actions among them as the ties that connect them are conduit and platform for information and influence resources to be transferred and manifested. This represents the basic utilitarian concept of social capital. However, extant discourse of organizational social capital has largely been concentrated on permanent organizational settings. But because such a utilitarian concept should be free from organizational-setting specific application, and we would argue that with the construction project peculiarities, social capital may be more relevant to project organizing. In this paper, we explore the concept's applicability in the more volatile and dynamic construction project organization. We aim to explore the forms and manifestation of social capital in project settings. We accomplish these tasks by a vignette derived from a case study of a building construction project in Hong Kong. The vignette allows us to present a part of the full-scale case study that is directly relevant to the research objective hence enabling a more focused discussion on the phenomenon. We first provide a brief overview of social capital in the next section, follow by the development of a proposition, the research methods, the vignette proper, and the formulation of a theoretical framework informed by the literature and the vignette.

2. Social capital in construction projects

Construction project is a network-based organization that consists of a variety of participants with different expertise all taking part in the project at various times (Styhre *et al*., 2004). The relationships among the participants, specifically, the goodwill generated among them (Adler and Kwon, 2002), represents social capital of the group. The project participants and the relationships among them form a project social network. It is this social network that allows resources to be accessed giving rise to project social capital. Although a temporary system, a project organization is nevertheless characterized by factors that are relevant to the development of social capital. First is the characteristic of interdependence. Interdependence arises from the interconnections between decisions and actions of project participants. Because of interdependence, participants need to rely on others to complete collective tasks. This high level of mutual interdependence provides and promotes social capital by increasing the opportunity of participants' interactions (Nahapiet and Ghoshal, 1998).

The second factor is the intensity of interaction. Similar to permanent organization, project organization provides a community, a space for bringing together project participants for actions and interaction (Nahapiet and Ghoshal, 1998). Project organization creates a range of contexts and occasions for the interactions of participants. It is through these interactions project organization provides opportunity for sustained socialization which is essential for the creation and maintenance of networks and social relationships (Nahapiet and Ghoshal, 1998) – the bedrock of social capital. However, because project organization is established for a specific purpose to be realised in a definite time, the intensity and dynamics of the social interactions in project organization are much higher than that in the permanent organization, therein lie the increased importance of social capital. In project organization, both the participants and their organization are entities in their own right that possess unique dynamics and operational logics. Because project works are largely context-specific, process- and action-based, the group dynamics are likely to be the result of participants' interactions and the patterns of social relations established by the participants (cf. Rizova, 2007). Under these circumstances, social capital that is engendered among the participants will likely affect the group performance, and ultimately the project performance.

Third, in project organization, participants have diverse specialties, facing tensions between autonomy requirements and simultaneous embeddedness within both their own parent and project organizational settings, and needing to constantly adapt to the emergent situations consequential of on-going flux and fluidity of operational circumstances (Gode-Sanchez, 2010). As projects – network type organizations – often lack a central authority (Poldony and Page, 1998), the coalition formed by project participants requires social mechanisms such as trust and reciprocity to function effectively (Jones *et al*., 1997; Powell, 1991). There is an acute need for participants to uphold a sense of obligation among themselves instead of taking advantage of the trust prevalent within the group.

Finally, there is the demarcation of social boundary of project organization. Although permeable to some extent, project organization nevertheless has social boundary that separate members from non-members (cf. Bourdieu, 1986). In this sense, project organization can be considered as "closed." This closure is conducive to the development of norms, identity, or even trust among the participants. It is this feature of closure that leads especially to the development of the cognitive and relational type of social capital (Nahapiet and Ghoshal, 1998; Coleman, 1990).

In sum, in project organization, the invocation and utility of the social capital concept are highly relevant. Social capital among participants is necessary because project organizational processes are socially constituted. Participants negotiate, refine, and achieve a shared understanding through interactions, sense-making and collective learning (Ayas and Zeniuk, 2001). Under the volatile and dynamic project environment where the practical norms governing the joint actions among participants are unstable consequential of the continuous flux of changes effectuated by the local situation at a particular time (Cicmil and Marshall, 2005), team members will need to network with a range of other participants to make sense of project organizational processes (Newell *et al*., 2004). Network facilitates these processes through the transfer of ideas. Project organizational network becomes a conduit for processing and moving this knowledge.

3. The three dimensions of social capital

We adopt the three-dimensional conception of social capital propounded by Nahapiet and Ghoshal (1998) in the present study for its applicability in organizational settings (Bolino *et al*., 2002; Koh and Rowlinson, 2011; Maurer and Ebers, 2006) - the structural, cognitive, and relational dimensions. The *structural dimension* concerns the properties of social system and the network relations as a whole. It refers to the impersonal configuration of linkages between persons or social units. An important facet under this dimension is the network ties between project participants. It concerns the presence or absence of ties between participants (Nahapiet and Ghoshal, 1998), and the extent to which participants are connected (Bolino *et al*., 2002). Another facet is the appropriable organization which deals with the existence of networks created for one purpose that may be used for other purposes (Coleman, 1988; Nahapiet and Ghoshal, 1998). Generally, these connections among participants significantly influence information (Krackhardt and Hanson, 1993) and influence-based resources (e.g. legitimacy and authority) (cf. Adler and Kwon, 2002; Poldony and Page, 1998) transfer among them, and the execution of organizational activities (Shah, 2000). As transfer channel (Bresnen *et al*., 2005), structural dimension represents a conduit that enables value generation for the project group. The conduit connects the group members while the value generated provides the reason for members to engage and invest in social relations. In this sense, the structural dimension provides an opportunity for the transaction of social capital (Adler and Kwon, 2002).

The *cognitive dimension* refers to those aspects that provide shared representations, interpretation, and the system of meaning among group members (Nahapiet and Ghoshal, 1998). Cognitive dimension, hence, concerns the extent to which members in a social group share a common understanding or perspective (Bolino *et al*., 2002). It refers to the similarities of group members' cognitive schemes (Maurer and Ebers, 2006). This shared aspect of social capital provides group members with a common perspective which enables the development of similar perception and interpretation on the events encountered within the group. This shared perspectives, interpretations, and orientations facilitate the exchange of information (cf. Boland and Tenkasi, 1995). When manifested as shared goals, the cognitive dimension facilitates a shared approach to accomplish group tasks. In project organization, because participants often have different goals, shared interpretation enables more effective negotiation among participants. In addition, this shared aspect of social capital provides a sense of belonging and identity (Bresnen *et al*., 2005) which may be useful in directing and focusing efforts of project participants with disparate objectives.

The *relational dimension* describes the personal relationships people developed among themselves through the history of interactions (Granovetter, 1992) (no less in construction project settings). It concerns interpersonal connections that are affective in nature (Krackhardt, 1992). It focuses on the quality or nature of those connections or relationships in terms of trust, intimacy / closeness, liking, etc. (Storberg-Walker, 2009; Bolino *et al*., 2002), and reciprocity and emotional intensity (cf. Granovetter, 1973). Among the various facets of relational dimension, trust has received much attention in organizational research (cf. Yang and Farn, 2009; McEvily *et al*., 2003a). Trust is needed for participants to work together in a project (cf. Leana and Van Buren, 1999). High degree of interdependence implies that project participants must exchange information and rely on other participants to accomplish collective task. However, each participant does not have complete control over, nor is in the position to fully monitor others' behaviors. To exacerbate the situation, participants cannot assume that their interests and goals are fully aligned (McEvily *et al*., 2003b). As such, each participant "controls" the other's fate thereby imposing the same threat to one another. These requirements of control and threat give rise to the need for participants to expect and be receptive to trust and trustworthy behaviors (Meyerson *et al*., 1996). Under these circumstances, trust is required as an input condition in project to stimulate supportive activities in the uncertain or risky project settings (Luhmann, 1988).

4. A proposition

Preceding discussions imply that social aspects are crucial in project organization because the type of actions involved is usually non-routine, dynamic, and emergent. To coordinate the actions of various constituents, project participants have to act under the conditions of ambiguity. Participants must negotiate a shared understanding of the contexts they are in (a cognitive dimension of social capital), look for the sources of information within the network of participants (a structural dimension of social capital), decide who to be trusted and depended on (a relational dimension of social capital), develop rules and norm for actions (cognitive and relational dimensions), and then distribute work among themselves and monitor the progress toward the goals (cf. Hackman and Morris, 1978). For the accomplishment of these goals, the social structure, the roles, norms, and trust – i.e. the social capital – is critical for it provides the foundation for ongoing interaction of participants (cf. Orlikowski, 2002). Because purposive interaction among project participants can be conceptualized in the present study as project organizational processes (e.g. adaptation, integration, cooperation, etc.) social capital can be seen to serve as a substrate on which these interactions take place (cf. Nohria and Eccles, 1992). The network of relationships among the project participants may offer mutual support for the cultivation of reflective practices. Through a complex process, social capital is created and sustained. Hence, because the concept of social capital represents primordial features of social activities, it provides the conditions necessary for project organizational processes to take place, and those processes, in turn, contributes to project success. In addition, to the extent that project participants can rely on project organizational control and role-based coordination for task performance and the social capital that resides with participants may lie dormant unless actively seek out and act upon, the impact of social capital on project outcome is likely to be indirect. That is, project success is influenced more directly by the participants' interaction in terms of for example, integration and cooperation, and these interactions are influenced by the relationships and social structure established within the project organization. In essence, our proposition is that: *the impact of social capital on project success is mediated by project organizational processes*.

5. Research methods

We examine the preceding proposition with a vignette derived from a case study of a building construction project in Hong Kong – the *Project Housing*. We use the peculiar structural form prevalent in the project – known simply as the "*working sessions*" – to explore the issues. Although the vignette utilizes only parts of the case study data, but because it is possible to examine the contextual conditions in which project participants encounter within project organization with case study (Yin, 2003), the vignette does allow simultaneous in-depth understanding of the effects of social capital and a broad understanding of related issues, processes, and dynamics of project team interactions. The approach also illuminates the process oriented and temporally bounded phenomenon (Molina-Azorin, 2011). The use of case study to explore organizational social capital is appropriate. Previous studies had adopted the design to study the phenomenon in the context of knowledge management in construction firms (Bresnen *et al*., 2005; Styhre, 2008).

We adopted the strategies of triangulation of data sources, prolonged engagement, and persistent observation for data collection. Multiple data types were used including archival data, observations, and interviews (recorded and transcribed). In our explorations, we asked informants on their ideas of the applicability and manifestations of social capital in project settings, and how these impact upon project organizational processes and outcomes. Other data collection modes were also guided by the same line of enquiry. The review of archival records and interviews (and subsequent discussions of results) with the core project team members were conducted from May 2007 to May 2008, and observations were conducted at earlier times when the research team attended the site meetings and visits. 13 interviews were conducted with personnel from both the client and contractor organizations. We adopted thematic analysis for the study (Ritchie *et al*., 2003). Data from various sources were compared, contrasted, and inductively analyzed into forming indexes. Themes were formed from indexes sharing similar underlying concepts. The labels for indexes and themes were drawn from both the data and literature. Explanations were developed by linking themes and indexes through the search of possible underlying logics and comparing the schemes with findings of other studies. This way, theoretical validity of the study is ensured.

6. A vignette of the "*working sessions*"

6.1 Brief project overview

An overview of *Project Housing* is given in Table 1.

Table 1: Overview of Project Housing

Client type	Government department		*Project features:*
Contract sum	HK$434 million (initial value) (US$1 = HK$7.8)		The Phase 4 (of six phases) of public rental housing project involving the construction of three 41-storey blocks of about 2,300 domestic flat units, with auxiliary civil and structural works Publicly high visibility project with novel MGMP procurement arrangement Full compliance of the Independent Checking Unit (ICU) with the contractor's designs Numerous new initiatives that render the project a "research project" – new designs, administrative procedures, etc.
Contract period	36 months		
Contract type	Traditional design-bid-build, with six work packages under modified guaranteed maximum price (MGMP) arrangement with some contractor's design elements		
Project core teams	Two primary teams: the client (as both designer and project manager), and the contractor		

The contractor of the project was technically and managerially capable and cooperative with the client. The incorporation of contractor's design elements into the project called for full compliance to the Independent Checking Unit's (ICU) requirements. Handling the ICU submissions and approvals had become significant affairs in *Project Housing* so much so that the project architect had resorted to convening frequent design meetings known as the "working sessions" by the team members to manage the design-related issues and complications. The working session is a special arrangement for parties "to discuss the design and the site construction sequence and the daily administration works. They (referring to the project core teams) can discuss all the requirements at the workshop and prepare the drawings accordingly. This has in fact smoothened the process" (the client project senior architect, SA). Generally, in *Project Housing*, the new technical and the related managerial processes intertwined and posed challenges and complexity in project organizing for all parties in the project.

6.2 Structural dimension

In terms of the working sessions, the structural form was manifested in the internal network that interweaved the client, the main and the sub-contractors project personnel. For the client and the main contractor teams, multi-connections were formed in a closed network that facilitated information transfer both laterally and vertically across the hierarchies. An intriguing effect is the existence and effects of informal grouping that emerged from the working sessions. As a result of the amount of discussions that were needed in the design development activities, design meetings were organized with high frequency and intensity among a wide range of project participants spanning various hierarchies. The arrangement is informal. The project architect (PA) explained: "They would bring the drawings to the meetings and then architects and engineers would be sitting there to resolve the issues. Every issues, the design issue, the site issue, contract issue, everything can be discussed." This form of interaction brought about speedier issues resolution because the arrangement "helps to reduce unnecessary corresponding work" (PA). In addition, the intensive interactions of all parties (including the confiding of each other's constraints) and the willingness of all to collectively resolve the issues had fostered the core teams' group cohesion and trust. The PA proclaimed that by engaging in such high intensity interaction "we build up trust very efficiently because if we talk with the contractor, we understand that he is really thinking about how to resolve the issue for you and how to cooperate with you to do things better, you would trust them."

6.3 Cognitive dimension

The cognitive dimension can be encapsulated in the various forms of shared understanding that had emerged among participants. The forms included the common goals, the appreciation of each other's constraints, and project requirements. In *Project Housing* the core teams' common goals were timely completion and meeting project budget. However, coupled with the appreciation of other's constraints, together with the need to face the uncertainty and increased workloads for all parties, a sense of solidarity within the core teams had emerged. This atmosphere had instilled an increased sense of team cohesion and willingness to share responsibilities among the members. The late issuance of drawings by the client design team had been met by the main contractor with some re-planning works and with the corresponding award of time extension from the client – a mutual accommodation. The contractor's project manager (PM) made the point: "So we need to have a true partnering. No matter the problem is raised by any parties, we need to tackle it together to streamline and to minimize the time consumed to resolve the problem!" The core team became more cooperative through appreciating and accommodating each other's difficulties.

6.4 Relational dimension

The forms of relational dimension in *Project Housing* include team spirit, solidarity (as identified earlier), commitment, and trust among the core teams. Collegial spirit was highly evident in the project. Starting from the initial traditional role- and contract-based interactions, the relationships among the core team developed into a more humanistic nature through the socialization periods. After experiencing the mechanistic arrangement for some time, a less contractual approach emerged. The client SA recalled: "For a certain period of time, they [referring to the core teams from both sides] still get some kind of human relationships, and this is important and, under normal situations, we welcome this sort of arrangement because you are not only client-contractor relationships. We work in team so we consider ourselves as team members with common goal." It was observed that this collegial team spirit helped smoothening the work processes and communication. Along this line, the emergence of solidarity resulted from the need to deal with uncertainty and the increased workloads in relation to the novel procurement system and the string of new initiatives. Here, both teams were thrown into a common situation. This collective involvement had sensitized the members into experiencing a more acute awareness of the responsibilities bestowed upon them. The solidarity had culminated in the various episodes of ICU submissions and the client's supporting the main contractor initial failure with ICU's approval and later re-submissions. This solidarity had engendered a sense of support for the broad values (of getting ICU approvals and related project issues) and the cultivation of a sense of mutuality among members (Smith 2009).

6.5 Social capital and project organizational processes

The idea that social capital is foundational to the case projects participants' interactions, and by extension the project organizational processes among them, was pervasive among informants. As observed, social capital, as manifested mostly in good relationship and trust among the project participants facilitated interactions. This facilitation was realized through the adoption of a more trusting approach in certifying in-process work outputs. The contractor's building services coordinator of *Project Housing* exemplified the situation as: "The social capital, yeah, you talked about the trust and the relationship, and I would say that it would affect the project most because if we don't have the mutual trust between us and the client department, then it's very hard to carry out the work. If they don't have trust on us, they would probably inspect every details and it will affect the project progress." More generally, social capital provided the basis of positive interactions among project participants. It served to reduce or even remove the barriers between the interacting parties.

However, while acknowledging the foundational thesis of social capital in project parties' interactions, some informants held a somewhat conservative view on this relational asset. With these informants, their experience was that social capital was less reliable. This point was made by the client's building services engineer that in the government projects, project officials could not rely on relationships in getting the works done. Rather, they would choose to rely on project organizational processes for the "timely completion of the works" (client's building services engineer).

Notwithstanding the fact that it was the government officials who made those assertions and that they were subjected to the transparency requirements that somehow constrained their reliance on relationships, this line of argument does imply that social capital was indeed relegated to the background to facilitate project processes, and those processes were more directly contributory to the project outcomes.

7. A framework

Based on the analyses of the vignette, a social capital-based model of construction project management can be proposed. The model is depicted in Figure 1.

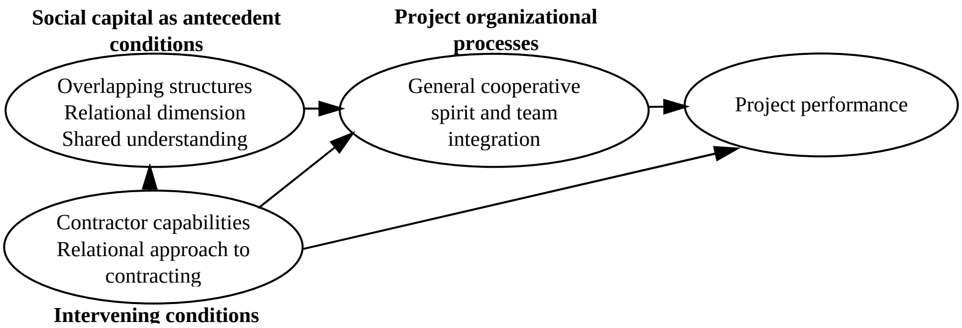

Figure 1: The social capital approach to construction project management

7.1 Social capital as antecedent

The phenomenon of "working sessions" has highlighted possible project structural design that entwines both the key personnel's human and social capital (e.g. the client PA and the contractor PM). Here, the human capital that embodied in the key personnel (e.g. technical and managerial capabilities) can be better exploited by the virtual of them occupying both advice and managerial networks, and simultaneously occupying the key positions in both informal and formal structures. In this way, their roles and responsibilities are in line with their centrality in technical- and managerial-advice networks. In terms of relational dimension, an important way is to create a social climate that promotes shared cognition among project participants – the extent to which participants know, recognize, and consider one another's needs and goals (Granovetter, 1992). As revealed in the vignette, this shared cognition that is manifested as empathy, acknowledging other's constraints, common goals, the alignment of understanding of the project requirements all provide a condition whereby participants show willingness to be accommodative that helps to brings about joint efforts.

7.2 Project organizational processes

The facilitative effect of social capital can be realized as the results of the benefits that can be derived from the configuration of project social capital. The combination of the three elements of social capital as observed here all help in achieving greater efficiency in the coordination of project task interdependencies (Coleman, 1990) by facilitating access to information that helps speeding up information exchange and processing (Gargiulo and Benassi, 1999), and promoting respect, trust, and trustworthiness between participants (Lin, 2001; Bourdieu, 1986).

7.3 Intervening conditions

Although the antecedent (in project social capital) and mediational variable (in project organizational processes) affect project performance, as revealed in the vignette however, the existence of other factors cannot be ruled out. These factors are encapsulated in the intervening conditions – contractor capabilities and relational approach to contracting. As revealed by the vignette and in line with literature, two types of contractor's capability are relevant: technical and organizational competencies (cf. Isik *et al*., 2009; Lokshin *et al*., 2009). The vignette contractor's use of the new precast façade construction and the achievement of the 6-day-per-floor cycle with that technology had all contributed to time achievement of the project. These technical competencies – a synergistic combination of construction methods, technology, and experienced technical staffs – have tremendously contributed to project performance. With respect to organizational competency, this capability is reflected through the contractor and client project teams in effective and efficient work organization. However, to realize this team capability, project team needs to be cohesive to ensure success of teamwork. Cohesiveness among team members can be achieved through a structural form that allows open communication between team members, good coordination of tasks, members individual's contribution, and the promotion of mutual support within the team (and from the parent company) (cf. Hoegl and Gemuenden, 2001). As revealed in the vignette, the interwoven formal and informal project structures had enabled high level of cohesiveness between both teams.

Another intervening condition is the effect of contract in project organizing - specifically, the extent to which contract can be used to promote collaborative working. In this situation, if the utility of contract is ubiquitous, and to the extent that contract serves controlling and coordinating functions, contract should be very detailed and should focus more on the positive provisions – in the line of what the parties want to collectively achieve and how – rather than solely on the negative safeguards. As can be inferred from the vignette, contract, in this manner, serves as a technical aid in the management of the relationships of the contracting parties, and is now placed in the social contexts under which it is used (Woolthuis *et al*., 2005). This contextualisation of contract is an attempt to make an otherwise seemingly detached document into one that is more aligned with the world of actual contracting practices (Cheung *et al*., 2006).

8. Conclusions

In this paper, we have demonstrated the applicability of the concept of social capital in construction project settings by delineating the manifestations of the forms and effects of social capital on project organizational processes with the use of a vignette. Although the atypical nature of the "working sessions" renders the invocation and explication of social capital concept more pronounced, the evidence have nevertheless pointed to the relevance of the concept in construction project settings. To this end, a few project managerial implications can be suggested. Although social capital of project organization is largely emergent and self-organizing, as revealed from the vignette and in line with literature, we suggest project leader to take a more balanced view of controlling and allowing some autonomy (Agterberg *et al*., 2010). The intervention along this line of thought, and in terms of the three social capital elements can be the encouragement of personnel in the formal strategic project structure to engage in informal interactions, the promotion of shared understanding and trust by exercising positive leadership.

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Emotional Intelligence in Engineering Project Teams

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Abstract

Emotional Intelligence (EI) has been associated with enhanced individual and group work performance. Despite tentative claims that it can improve the performance of project teams there has been little empirical research to confirm this assumption. The **aim** *of this paper is to examine the theoretical proposition and claims through in-depth case-based analysis. The objective is to examine the extent to which EI facilitates collaborative team working in practice and evaluate any normative potential to improve management practice. This study addresses this under-researched area by applying the Goleman and Boyatzis EI competency model to a project to examine the extent of collaborative working practices between different construction-related organizations – client, professional and contracting organisations – from which were drawn the personnel comprising the temporary multi-organisational project teams.*

A single case study is selected on the King's Cross Station Redevelopment Programme (KCSRP), located at a major rail terminus in the heart of London, UK. Network Rail commissioned this redevelopment project. The study used triangulation, including an innovative approach of filming meetings to measure the affect of EI in project teams. This helped address the common limitations associated with using conventional direct observation methods to achieve depth and rigor of analysis.

The case study findings of this research reflected evidence of certain competencies being displayed in project teams, which have contributed to related aspects of the KCSRP collaborative working strategy. Where other competencies were deficient this aligned with underperforming aspects of the programme's collaborative working strategy. Hence, the research concludes that EI facilitates the KCSRP collaborative working strategy and can therefore potentially enhance the effectiveness of project teams with appropriate management awareness, action and competency development.

The original contribution to knowledge arises from the depth of analysis around a single case, including the use of filming as a research method, to understand the contribution of EI and emotional competencies to collaborative working. The corresponding limitations of the study are the single case analysis, yet the study contributes to the growing weight of evidence supporting the pertinence of EI in project team working. Recommendations for management are presented in conclusion.

Keywords: Emotional Competencies, Emotional Intelligence, Project Teams, Collaborative Working

1. Introduction

Emotional Intelligence (EI) is associated with claims of enhanced individual and group work performance (e.g. Goleman, 1998a; Druskat and Druskat, 2006). Yet, the domain is contested (e.g. Matthews et al, 2002; Matthews et al, 2004; Zeidner *et al*, 2004) and there has been scant empirical confirmation related to project teams. The *aim* is to examine claims that EI enhances performance. The *objective* is to examine the extent to which EI facilitates collaborative project team working in practice by applying the EI competency model (Boyatzis *et al*, 2000; Goleman *et al*, 2002) to a multi-organizational engineering project team undertaking a major and complex infrastructure project. The organizations comprise the sponsor department in a national client body, professional and contracting organizations.

The literature review focuses upon EI and performance, particularly collaborative working strategies as a link between group behaviour and organizational operational performance. The research applied conceptual competency measures plus body language as a method of observing EI. A single in-depth case study is used, the King's Cross Station Redevelopment Program (KCSRP), comprising a set of integrated projects for a rail terminus redevelopment in the heart of London, UK. Network Rail as the sponsoring client commissioned the project. The study employed the innovative approach of filming meetings to measure the affect of EI on KCSRP project teams to help address common limitations of EI psychometric-style tests and questionnaires and of perceptual and indirect observation methods.

The case study found certain competencies evident in project teams, which contributed to the collaborative working strategy on KCSRP. A further set of competencies was found to be deficient and corresponded with underperformance of aspects of the Program's collaborative working strategy. The analysis concludes that EI facilitated the KCSRP strategy for collaborative working and can further enhance the effectiveness of engineering project teams. This makes an original contribution to knowledge on project team working and for the innovative methods for the observation of EI in operational contexts. The limitations are the single case analysis, yet the study contributes to the growing evidence of EI in project team working. Recommendations are presented in conclusion.

2. Literature Review

EI research has grown exponentially across disciplines, and management has been a mainstay. The scope of the review, therefore, needs clear parameters. Following a brief overview, the EI literature on performance plus group/team operations will provide the twin foci. Collaborative working provides the link between group behaviour and performance (Goleman, 1998a; Druskat and Druskat, 2006). The roots of EI are found in social intelligence. Salovey and Mayer formally defined EI as, *the ability to monitor one's own and others' feelings and emotions, to discriminate among them and to use this information to guide one's thinking and actions* (1990:189). A series of models have emerged, three of the main ones being the Salovey-Mayer model (1990), Bar-On's model (Bar-On *et al*, 2006) and Goleman and Boyatzis' (Boyatzis *et al*, 2000; Goleman *et al*, 2002) competency model. The strengths and weaknesses of each are summarized in Table 1.

The Goleman-Boyatzis model (Boyatzis *et al*, 2000; Goleman *et al*, 2002) is adopted for several reasons. It has been developed for group EI (e.g. Elfenbein, 2006) and explored in project teams (Druskat and Druskat, 2006). It covers competencies aligned to collaborative working strategies. Goleman (1998a) first proposed that EI benefited efficient and effective performance at work, which other work substantiates (e.g. Bar-On *et al*, 2006). High individual levels of EI mark out the "star performers" from other employees (Day and Carroll, 2004: 1444). Goleman (1998b) proposed that high EI levels were attributed to effective leadership. Some research findings have confirmed initial claims (e.g. George, 2000; Palmer et al, 2001). Watkin (2000) concluded that organizations with higher EI accrue higher growth, greater shareholder value and sustainable competitive advantage. An organization with such a profile arises from recruitment policies and criteria and/or employees with high EI self-selection into organizations with these (nascent) attributes. Mount (2006) found EI competencies improved effectiveness across a range of roles including project management. EI induces effectiveness amongst project managers (Muller and Turner, 2010) and induces improved teamwork (Elfenbein, 2006), norms facilitating group trust, efficacy and networks (Druskat and Druskat, 2006).

Table 1: Strengths and Weaknesses of EI Models

EI Model	*Strength*	*Weaknesses*
Salovey-Mayer Model	Empirically proven (unlike other models) not to represent conventional personality traits. Seen as more representative of a cognitive intelligence than other models. (O'Connor and Little, 2003). Its measurement is objective (Mayer et al, 2000a).	Criticized for as not constituting being a cognitive intelligence but a 'learned skill' (Landy, 2005). Poor predictive validity of workforce performance (Bradberry and Su, 2003). Ambiguity over what constitutes a correct (emotionally intelligent) response during objective measures (Pérez et al, 2005). Confirmed lack of cultural variation sensitivity (Salovey, 2006). Empirically confirmed measurement gender bias (Salovey, 2006; Day and Carroll, 2004). Weak correlation with the other two EI models (Van Rooy et al, 2005).
Bar-On Model	EI develops with age and can be developed via training and therapy. Emotional and cognitive intelligence considered to contribute equally to a person's general intelligence, thus indicating an individual's chances of succeeding in life (Bar-On, 1997).	Criticism that model has little to do with emotion or intelligence. Measures overlap with existing personality traits (Matthews et al, 2004). Limitations of self-report measurement (e.g. Zeidner et al, 2004).
Goleman-Boyatzis Model	Assertion that EI competencies can enhance human performance (especially in aat work context) (Goleman, 1998a). Plentiful studies verifying the predictive validity of EI and work performance (Goleman, 1998a; Watkin, 2000). Advocated as more important than IQ in determining life success. EI competencies can be learnt at any age (Goleman, 1998a). Proficiency in all 18 competencies is not needed (Druskat and Druskat, 2006).	Criticised for being existing personality characteristics (Davies et al, 1998). Criticised for not constituting a cognitive intelligence (Matthews et al, 2002). Criticism model does not constitute EI concept (Brackett and Mayer, 2003). Limitations of self-report measurement (e.g. Zeidner et al, 2004). Criticism that performance enhancing benefits are anecdotal and lack empirical research (Matthews et al, 2002).

Yet the link between EI and performance including group EI and team performance remains contested (e.g. Davies et al, 1998; Matthews et al, 2002; Zeidner et al, 2004; Landy, 2005). Following Goleman (1998a) and Druskat and Druskat (2006), we propose the behavioural link between group EI and operational performance is collaborative working. Anvuur and Kumaswamy's (2008) definition of collaboration follows, for example, Hamel et al (1989), where it involves short-term alliances between clients, designers, suppliers and facilities managers to deliver integrated project services across organisational boundaries. The definition of project performance is complex and largely dependent upon decision-makers' perspectives (e.g. Morris and Hough, 1987). It can be ascribed to time-cost-quality/scope (project operational performance), value delivered (functionality), and/or benefits in use (client/end-user operations). The focus here is the former yet extends beyond project tasks to include the collaborative service experience. Teamwork and collaboration is an EI competency (Boyatzis *et al*, 2000; Goleman *et al*, 2002), defined as *working with others towards a shared goal and creating group synergy in pursuing collective goals* for projects (Druskat and Druskat 2006:86).

A 'collaborative working strategy' was adopted by Network Rail (NR) for KCSRP (Mitchell, 2008). The strategy required adherence to a set of collaborative working values: a) unity of purpose, b) trust, c) win-win situations, d) interdependence, and e) the ability to challenge each other in the right way. The values were envisaged to inform a set of collaborative working behaviours, as follows:

- Talk first before taking other action, and listen to and consider other peoples' views.
- Do what we say we are going to do.
- Explain what we expect from other people and understand what they expect from us.
- Recognize achievements.
- See things from other peoples' perspectives.
- Be committed and professional.
- Be positive ambassadors for the program.
- Personally commit to the delivery of the project.
- Challenge below standard behaviours in a constructive manner.
- Be open with our problems and resolve them together as one team.

These behaviours provide an organizational context in which individual and group EI could be expected to be evident. The benefits were anticipated as: i) improved communications, ii) integrated team working, iii) improved team engagement and spirit, iv) sharing of resources and learning, v) expeditious resolution of issues, vi) proactive support, vii) greater innovation, viii) minimization of waste and inefficiency. The benefits constitute one possible assessment of performance, six of which EI could directly enhance, and EI could indirectly influence the remaining two benefits.

3. Methodology and Methods

The review supports the research question: *to what extent can emotional intelligence* (EI) *facilitate Network Rail's* (NR*) desire to implement a collaborative working strategy for the KCSRP*? Methodologically, there is controversy over EI theory and its models (Salovey, 2006). For example, combining ability and trait dimensions has been criticized (e.g. Bar-On, 1997). This has some logical rigor, yet atomization causes disconnection with the social construction of behavior and action in reality. Statistical analysis of atomized data can yield connections that are functions of mathematical logic, not actual processes.(Sayer, 1992). Behavior is informed by both trait and ability in practice, including collaboration for teams and in projects (Druskat and Druskat, 2006), in turn affecting project performance outcomes (e.g. Anvuur and Kumaraswamy, 2008).

A case-study approach is adopted for in-depth analysis of "how" and "what" questions. It *allows investigators to retain the holistic and meaningful characteristics of real-life events* (Yin, 2009:4), Case analysis trades off depth against generalization from any findings. The single case was KCSRP, NR being sponsor and client and its contractors being the prime actors for the study: TW Construction (acquired by VINCI in 2008) and Fourway Communications (FC) as main contractors and Arup as consultant engineers. As significant organizations they establish trend others may follow. Other methodological problems include the unreliability of self-report EI measures (e.g. Zeidner et al, 2006) and the scoring measures (Matthews et al, 2004). Locke (2005) questioned whether people are able to monitor and discriminate between their emotions and emotion of others exhibited through behavior. Such assessments may not be measures for EI but a learned skill. Therefore self-report techniques were avoided in favour of direct observation. However, observation poses problems of interpretation by the observer. One strategy of mitigation is to capture data observed which is retained in tact after the event. Filming offers an anthropological means to observe and retain data in tact: *…videotape records retain sample sequences of observed activity for later scrutiny* (Schaeffer, 2003:255).

Filming as an observational technique is innovative for management and project management research. Captured footage increased the reliability and included information that might otherwise have been missed. Yet, filming introduces new challenges: room size, the number of meeting participants and their visibility, the ability to capture every meeting participant or to gain a full 360-degree view of participants. Further challenges include participants being distracted by the camera and any individual discomfort at being filmed. Confidentiality issues are heightened, for example will line managers view the footage. Assurance was provided by fully informing participants of the purposes for the research and a confidentiality form was signed. Subsequently, all individual and organizational actors gave consent for publication, including use of visual material. Only one project member had refused to participate and meetings were selected that excluded the person's membership. A pilot was conducted on the 21st June 2010 to establish practical needs for satisfactorily filming future meetings in an unconstrained way. As direct observation can affect how events proceed (Yin, 2009), it was decided to film each type of meeting at least twice (Table 2). Participants were also informed that the camera would not always be switched on, so more meetings were set up for filming to facilitate the participants getting used to the camera presence. This appears to have been effective, participants providing feedback that they forgot the camera was in the room. Fourteen meetings were filmed – see Table 2. Body language was used for EI observation, raising socio-psychological issues of methodology and methods. EI competencies were mapped against key body language dimensions (e.g. Wainwright and Thompson, 2010; Ribbens and Whitear, 2007; Bowden 2010; Russell and Fernandez-Dols, 1997).

The analysis used abductive reasoning to frame the research questions from the literature, used inductive compare and contrast methods for the organizations and actors, and took the opportunity to use observation to evaluate the theoretical frame of reference applied.

Table 2: Schedule of Filmed Meetings

Type of Meeting	*Date*	*Time*
Western Concourse Progress	06/28/2010	1100-1230
Western Concourse Progress	07/12/2010	1100-1250
Technical Queries Progress	06/29/2010	1200-1300
Technical Queries Progress	07/13/2010	1200-1220
Suburban Train Shed Weekly Progress	06/30/2010	1300-1400
Suburban Train Shed Weekly Progress	07/07/2010	0900-1000
Suburban Train Shed Weekly Progress	07/14/2010	1300-1345
Arup Weekly Review	06/29/2010	1600-1800
Arup Weekly Review	07/06/2010	1600-1800
Arup Weekly Review	07/27/2010	1600-1800
Weekly Communications Meeting	07/28/2010	1100-1230
Weekly Communications Meeting	08/04/2010	1100-1230
Network Rail/Taylor Woodrow Board Meeting	06/24/2010	1430-1700
Network Rail/Taylor Woodrow Board Meeting	07/22/2010	1430-1700

Table 3: Schedule Mapping Body Language against Emotional Intelligence Competencies

Emotional Intelligence Competencies	*Body Language*
Empathy	<u>Active & concerned listening:</u> 1. Leaning forward or head tilted forward 2. Head cocked (slanted to one side) 3. Facial and body expression mirroring 4. Head supported by thumb & 1st two fingers 5. Index finger to chin touch 6. Steepled hands pointing forwards 7. Eye contact 8. Occasional Nods
	<u>Disinterest and not listening:</u> 1. Pushing chair back from table 2. Stacking paperwork on the table, eating, drinking, reading notes 3. Looking down or dropping head during conversation 4. Chin propped in palm during conversation 5. Looking towards ceiling or at watch/phone
Transparency	<u>Deceit & defensiveness:</u> 1. Scratching (especially back of head) 2. Excessive fidgeting 3. Nose touching or covering (by listener also) 4. Blushing 5. Becoming more expressive constructing (i.e. waving hands, being long-winded) 6. Avoid answering & pretend to not understand question 7. Eyebrows rise & come together (hidden fear) 8. Eyebrows pulled down & inward (hidden anger) 9. Eyes move to top left (hence constructing a thought rather than remembering it) 10. Avoid eye contact (or eye rubbing) 11. Touching ear lobes 12. Folded arms
	<u>Open, honest & trustworthy:</u> 1. Palms facing up or outwards 2. Open gestures from within the 'TruthPlane' (horizontal plane extending out 180 degrees from the navel)
Optimism	<u>Positive attitude:</u> 1. Leaning forward
	<u>Negative attitude:</u> 1. Leaning backwards
Teamwork & Collaboration	<u>Agreement or rapport:</u> 1. Posture congruence (similar postures among group members)
	<u>Rejection, dismissive & disagreement:</u> 1. Brushing hand across knee or thigh 2. Shrugging 3. Head shaking 4. Folding arms & leaning back in chair 5. Fast nodding 6. Sitting back in chair & looking downward 7. Turning away when talking 8. 'Picking lint' (imaginary fluff off clothes) 9. Hand on shin of crossed leg
Self-confidence	<u>Anxiety:</u> 1. Shoulders tensed & raised 2. Excessive self-comfort rituals (facial touch or self-stroke) 3. Nail & lip biting 4. Tapping 5. Excessive straightening gestures (i.e. ties, hair, pens) 6. Nervous laughter 7. Wide eyes

	Confidence & assertiveness: 1. Upright relaxed posture 2. Calm and open gestures 3. Good physical distance (not too close or distant) 4. Good eye contact 5. Loosely clasped hands held at waist height 6. Steepled hands (pointing upwards) 7. 'Four cross position' (sat with ankle resting on other knee & hands clasped behind neck with elbows outstretched)
Conflict Management	*Conflict:* 1. Arms folded high on chest 2. Aggressive gestures (i.e. Pointing, chopping or dismissive hand-flapping, clenched fist, fist punched into opposite hand, desk thumping) 3. Constant unbroken staring 4. Baring or jutting lower jaw teeth 5. Increased blink rate 6. Self-harm (scratching, hitting-self) 7. Curling up of top lip
	Resolution: 1. Leaning forward 2. Raised slightly arched eyebrows 3. Relaxed lips 4. Palms turned out 5. Mirrored body language 6. Mirrored facial expressions 7. Nodding in time with other person's words 8. Person agreeing facing opponent 9. 'Pulling-in' gestures (by speaker showing acceptance) rather than 'pushing' behaviours.
Inspirational leadership	1. Confident posture

4. Findings and Analysis

Table 4: Summary of Network Rail Climate Assessment Survey for KCSRP

Climate Assessment Tool Item	*Range of Scores (%)*	*Average Score (%)*
Perception client and contractors work well together	65-77	68.50
Perception that the client and contractor will adopt a win-win approach (looking for mutual benefits)	61-73	70.00
Perception there is a good level of trust across the project team	56-83	68.75
Belief that project members know what they are accountable for	67-77	71.00
Feeling that project members are inspired by delivery team senior managers	63-69	66.50
Perception there is not a blame culture in the project team	61-70	65.00
Confidence the project will be delivered within programme	56-75	65.00
Belief that present work practices will overcome any future problems	61-73	69.00
Levels of understanding each others needs	67-73	70.50

Source: Network Rail internal documentation, 2009

The CAT survey provided a baseline for the empirical work and a benchmark to aid subsequent inductive analysis. The empirical findings first cover the EI competency measures (Tables 5 and 6) and, second, body language observation referred to in Table 3. The average score for each EI competency achieved by the individual organisations for each of the 14 meetings is set out in Table 5. Table 6 outlines the total of the average scores for each competency achieved by the individual organisations over the series of meetings for that project team, for example the range of average scores by Arup during the three Arup Weekly Review Meetings was -1 to +4.

Table 5: Average EI Competency Scores by Organization per Meeting

Meeting	*Organization*	*Empathy*	*Transparency*	*Optimism*	*Teamwork & Collaboration*	*Self-Confidence*	*Conflict Management*	*Inspirational Leadership*	*Achievement Orientation*
Technical Queries Progress 1	Taylor Woodrow	-1	-1	-1	1	-1	0	1	1
	Network Rail	0	0	0	0	-1	0	0	0
Technical Queries Progress 2	Taylor Woodrow	1	0	0	-1	-1	0	1	0
Western Concourse 1	Taylor Woodrow	0	0	1	1	0	1	-1	0
	Network Rail	0	-1	-2	2	2	1	1	1
Western Concourse 2	Taylor Woodrow	0	1	1	-1	0	-1	-1	0
	Network Rail	0	-2	-3	3	1	-2	0	2
Suburban Train Shed 1	Taylor Woodrow	1	1	1	1	2	0	0	1
	Network Rail	1	1	1	0	1	0	2	1
Suburban Train Shed 2	Taylor Woodrow	1	2	0	0	0	0	0	0
	Network Rail	1	0	0	0	0	0	1	1
Suburban Train Shed 3	Taylor Woodrow	1	0	0	0	2	0	1	1
	Network Rail	1	0	-1	0	0	0	2	1
Board 1	Taylor Woodrow	1	1	0	1	-2	0	0	2
	Network Rail	2	1	0	2	2	0	1	1
Board 2	Taylor Woodrow	1	2	1	1	1	0	2	3
	Network Rail	1	1	1	2	2	0	2	2
	Fourway Communications	1	0	0	0	0	0	0	0
Arup Weekly Review 1	Arup	1	0	0	2	0	0	1	1
	Network Rail	2	0	0	3	1	0	2	2
Arup Weekly Review 2	Arup	1	0	0	1	1	0	1	0
	Network Rail	1	0	0	-1	3	0	1	0
Arup Weekly Review 3	Taylor Woodrow	1	1	-1	1	0	0	2	0
	Arup	0	-1	0	1	1	0	1	0
	Network Rail	1	2	0	2	3	0	1	2
Weekly Communications 1	Fourway Communications	-1	-1	1	1	0	-3	-2	1
	Network Rail	0	-1	0	-1	0	-1	-1	1
Weekly Communications 2	Fourway Communications	1	-1	0	0	-1	0	-2	-1
	Network Rail	1	-1	-1	1	1	0	1	2

The two Technical Progress Queries meeting are considered first. A large number of both low and negative scores were evident, ranging from -1 to 1. The meetings were notable for the apparent lack of self-confidence displayed by both NR and Taylor Woodrow (TW) members. TW members demonstrated some leadership, collaborative and achievement competencies, especially for Meeting 1 (Table 5). They took personal responsibility for addressing important issues and suggested innovative solutions. Yet, meetings were also characterized by a lack of optimism – during the first meeting they were pessimistic when discussing the likelihood of past problems potentially re-occurring and in the second meeting they used negative banter regarding the failure of a representative from another contractor to comply with a desired action – whilst the client failed to show positive leadership.

Table 6: Total Average EI competency Scores by Meeting Type

Meeting	*Organization*	*Empathy*	*Transparency*	*Optimism*	*Teamwork & Collaboration*	*Self-Confidence*	*Conflict Management*	*Inspirational Leadership*	*Achievement Orientation*
Technical Queries	Taylor Woodrow	0	-1	-1	0	-2	0	2	1
Progress	Network Rail	0	0	0	0	-1	0	0	0
Western Concourse	Taylor Woodrow	0	1	2	0	0	0	-2	0
	Network Rail	0	-3	-5	5	3	-1	1	3
Suburban Train Shed	Taylor Woodrow	3	3	1	1	4	0	1	2
	Network Rail	3	1	0	0	1	0	5	3
Board	Taylor Woodrow	2	3	1	2	-1	0	2	5
	Network Rail	3	2	1	4	4	0	3	3
	Fourway Communications	1	0	0	0	0	0	0	0
Arup Weekly Review	Taylor Woodrow	1	1	-1	1	0	0	2	0
	Arup	2	-1	0	4	2	0	3	1
	Network Rail	4	2	0	4	7	0	4	4
Weekly Communications	Fourway Communications	0	-2	1	1	-1	-3	-4	0
	Network Rail	1	-2	-1	0	1	-1	0	3

The Western Concourse Meetings were significant. A distinct lack of optimism existed amongst NR representatives (scoring -5, Table 6). They were concerned that risks would materialize. The TW project manager suggested several solutions to address risk, but NR representatives remained unconvinced and were pessimistic. This was reflected in body language displayed at meetings (Figure 1 in conference presentation (CP)) with NR representatives leaning back in their chairs in response to suggestions made. On the other hand, TW representatives lacked leadership, constraining their ability to persuade and influence. The second of the two meetings was marked by resultant conflict concerning delays and mitigation plans. Aggressive gestures were repeatedly used (Figure 2 in CP). Yet collaborative objectives were maintained (Figure 3 in CP), applying related EI competencies (Tables 5 and 6), for example when an NR representative asked, *"Is there anything NR can do to assist?"* The three Suburban Train Shed Meetings contained inspirational leadership from the NR project manager and empathy was in evidence. For example, the project manager motivated the contractor to improve work area cleanliness following complaints. Other members were receptive and empathetic (Table 6). Good eye contact, nodding as indicators listening and internalization and other gestures provided visual evidence in support (Figure 4 in CP).

The two Board Meetings observed showed teamwork and collaboration (Tables 5 and 6). In one incident the TW programme director reported collaborative working behaviours as highly effective on a package of work. Discussion considered rolling out these behaviours on further work package. One occasion involved the client calling for collaboration when one contractor complained another was causing delays and agreement was reached to do so. The meetings displayed high levels of the achievement orientation competency, particularly during a safety review that led to discussing innovative ways to prevent damage to a hoist re-occurring and to improve site security following a reported theft. The transparency competency was used, for example through honest responses to a question on the rigor of risk assessment: *"I couldn't hand on heart say it is done consistently and rigorously enough"*. Members felt secure, the NR program director applauding the efforts made to create safe site processes, *"we are doing all the right things"*, which further encouraged transparency. Open hand gestures in the "truthplane" of 180° around waist level were used (Figure 5 in CP). Transparency can lead to necessary criticisms and reduced optimism in order to improve project action – one event induced a contractor programme director to hold his head in his hands with eyebrows raised for around a minute after everybody else had left one meeting, perhaps reflecting fear (Figure 6 in CP; cf. Table 5).

Arup Weekly Review Meetings exhibited a lack of transparency amongst Arup members (Table 6). Defensive, closed gestures were observed (Figures 7 and 8 in CP). A pessimistic tone was adopted; yet there were positive efforts to forge collaborative working from Arup and NR representatives with high levels of self-confidence and leadership present (Table 6). The Weekly Communications ("Comms") Meetings were conducted with conflict in the absence of effective conflict management (Table 6). For example, conflict around a dust problem escalated into aggressive behavior from the contractor and weak leadership on the client side.

Analyzing EI competency for each organization, combining the KCSRP CAT survey with the average EI competency scores (Tables 4 and 6), TW and NR showed high levels of empathy and TW displayed transparency. NR displayed teamwork and collaboration as their policy promotes, self-confidence, inspirational leadership and an achievement orientation. Negative EI competency emerged for Arup regarding transparency and for FC regarding transparency, self-confidence, conflict management and inspirational leadership. Whilst the observed meetings and individual EI competencies for the four organizations embodies some selectivity, reasonable levels of overall collaborative practices were found from the three data sources: the KCSRP CAT survey, EI competency scores, and filmed body language. Lack of transparency, apart from TW representatives, was the dominant shortfall, frequently coupled with low optimism. It is probable that similar types of patterns would be in evidence in other meetings as representatives are not only mobilizing their personal EI competencies, but are doing so in representing their organization and the organizational interests. This could be expected to induce organizational consistency from key decision-makers.

5. Conclusion

The research has examined the extent EI facilitates collaborative working. It has done so in the context of the NR collaborative working strategy for the KCSRP. This research makes an original contribution to that project and construction literature by demonstrating that EI competencies in group working make positive contributions to collaboration. This is demonstrated through EI competency measures, and supported with evidence from a CAT survey and body language analysis.

The use of filmed observation makes a contribution to the development of research methods. Further contributions arise from the interdependent nature of EI competencies where the coupling of positive competencies and also the coupling of competency lacking that reinforce negative trends. The evidence shows scope for EI competency management, namely commitment to EI team development.

Limitations cited in the EI literature were addressed by avoiding dependence upon self-reporting and application of triangulated data to help eliminate analytical bias. Yet, subjectivity was still present, particularly how camera presence may moderate behavior and interpreting filmed observation. Finally, there is the problem of generalizing findings from case analysis. Despite the limitations, sufficient evidence has demonstrated the value of EI in collaborative teamwork to drive up performance. Organizational boundaries are socially constructed artefacts to manage project markets and EI competencies provide one means to facilitate management across organizational boundaries.

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Reproduction of exchange relationships: Changing focus from organisations to individuals

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Abstract

That organisations collaborate on a firm to firm basis is an assumption which underpins much of the literature on inter-organisational relationships and supply chain integration, both in the generic literature as well as in the construction oriented. The exchange relationships on an organisational level, however, are constituted of one or several interactions on interpersonal level. With the interpersonal level as unit of analysis, this paper aims to answer how dyadic exchange relationships are produced and reproduced.

Investigation of dyadic exchange relationships between contractors and subcontractors has been conducted through 15 interviews with site managers from the contractors and foremen from the subcontractors. Findings show that the individuals within both dyads of the exchange relationship play important roles in the outcome of the project and the specific relationship. Despite this, the organisational focus of procurement of subcontractors tends to be highly price-driven. Site managers and subcontractors' foremen, however, tend to bypass the price-driven procurement approaches by offering their preferred counterparts possibilities to recalculate their quotations and adapting prices according to individuals.

By narrowing the range of procured subcontractors and focusing on the use of core teams based on matching of individuals within the teams, a potential improvement in the construction supply chain can be seen. By changing the focus of the concurrent research within construction management from organisational level towards interpersonal level, new perspectives may also be elucidated and exchange relationships between contractors and subcontractors might be better understood and explained.

Keywords: Inter-organisational relationships, interpersonal relationships, Contractor-supplier relations, Supply chain integration, Subcontractors

1. Introduction

That organisations collaborate on a firm to firm basis is an assumption which underpins much of the literature on inter-organisational relationships and supply chain integration, both in the generic literature (Emberson and Storey, 2006) as well as in the construction oriented (e.g. Bankvall et al., 2010, Eriksson, 2010). The forces which are affecting the development of inter-firm relationships may, however, be derived from three different levels: institutional, organisational and interpersonal (Marchington and Vincent, 2004). At the institutional level, there are national and regional norms and standards empowered through trade associations and professional bodies. At the organisational level there are the forces of previous business relations on both local and national level as well as inter-firm dependency. At the interpersonal level, the breadth and depth of contacts between supplier and customer is considered which concerns the day-to-day interactions between boundary spanners at different levels of the organisations (Marchington and Vincent, 2004).

In order to fully understand how firms interact, an investigation of the operational exchange relationships is essential and "one must be more sensitive to the local contingencies on those boundary spanning persons and processes than to some overall organisational characteristic which may have little predictive or explanatory power" (Leifer and Delbecq, 1978, p. 48). Even though contemporary research argue that project performance is negatively affected mainly by delays in labour flow together with material flow and information flow (Hatmoko and Scott, 2010), the literature on inter-organisational relationships offer sparse discussion of the processes that characterize interpersonal relations within or between organisations (Marchington and Vincent, 2004).

During the past decades, the construction oriented literature regarding inter-organisational relationships and supply chain integration mainly has focused on the client-contractor relationships (Bemelmans et al., 2012, Fernie and Thorpe, 2007, Saad et al., 2002). The perspective of the contractor-supplier relationship has, however, gotten increased attention during the last few years where strategic purchasers' perception on efficient relations has been explained (Frödell, 2011) and successful examples illustrated of construction firms adapting cooperative integration of material suppliers (Nordin et al., 2010). With some exceptions (e.g. Dainty et al., 2001, Winch, 2001), the collaboration with and integration of subcontractors, is still scarcely researched. With the interpersonal level as unit of analysis, this paper aims to answer how dyadic exchange relationships between site managers and subcontractors' foremen are produced and reproduced.

2. Theoretical framework

The point of departure is the governance structures which are proposed by Williamson (1973, 1991) and explained as markets and hierarchies. By the argumentation of markets and hierarchies and the in-between mode hybrid, different kinds of areas for transactions to be executed on are defined. This is followed by the perspective of the individual and how the organisational and individual forces might interplay during reproduction of exchange relationships.

In accordance with Thompson (1967), who states adjustment and adaptation to be the central question in inter-organisational constellations (boundary-spanning components of organisations) in contrast to coordination as for intra-organisational questions, Williamson (1991) points towards adaptation as an influencial attribute when investigating inter-organisational constellations. In total, five attributes differentiate the governance structures in markets from hierarchies: adaptation through autonomy, adaptation through collaboration, incentive intensity, administrative controls, and contract law (Williamson, 1991). Markets are argued to exist when transactions are executed between independent buyers and sellers and the price is set by the autonomy of the market, the supply and demand. Hierarchies or unified governance are present when full integration has taken place and the transaction is completely taken of the market. As markets and hierarchies are the extremes of a continuum, the in-between mode – hybrid governance structure – have been referred to as a coordination mode (Grandori, 1997) and as relational contracts (Winch, 2010). While some of the studies on governance structures has characterised the in-between mode as an additional third mode with its own characteristics, many studies on inter-firm organising has, however, been managing the governance through one single broad mode of organising argued as an intermediate generic mode stretching between markets and hierarchies (Grandori, 1997).

Based on asset specificity and frequency of transaction, four governance alternatives have been argued as relevant for the construction industry (Winch, 2001): sequential spot-market where the asset specificity as well as the transaction frequency is low; consortium where the asset specificity is low and the transaction frequency is high; joint-venture when the asset specificity is high as well as the transaction frequency and quasi-firm when the asset specificity is low and the transaction frequency is high. As for the traditional trades of subcontracting, sequential spot-market is most common where one firm might be exchanged for another relatively easy (Winch, 2010). Even though similarities are many with the market governance, sequential spot contracts are still argued as a relational contract, i.e. a hybrid mode (Winch, 2010). When transaction frequency rises between two firms, quasi-firms exists, which is an intermediate between the bilateral and unified (hierarchical) governance structures and also an intermediate between relational and neoclassical contracting (Eccles, 1981).

The perspective of governance structures does, however, take an inter-firm perspective of the exchange relationships. This despite that organisations are constituted by individuals and all individuals do not act in a unison way and not always in the direction of the organisation as such (Emberson and Storey, 2006). When discussing exchange relationships it might, however, be difficult and even unlikely for individuals acting within the operational core of the company to initiate collaborative approaches towards external actors unless they have the support from the company (Marchington and Vincent, 2004). The contradictory perspective of the organisation and the individuals has been articulated by Bryman et al. (1987, p. 264) by stating that ”although the market transaction may fundamentally determine the approach to relationships between the parties, the noticeable feature is the attributed importance of interpersonal relations in avoiding contractual stand-offs”. Hence, within the contractor-supplier exchange relationship they are identifying the importance of the individual. In order for procurement to have any influence on the corporate strategy and hence the organisational perspective, a change of the price-driven procurement methods has been argued as a must (Cousins and Spekman, 2003). Similarly, in order to facilitate cooperation in exchange relationships, exchange relationships “should be structured in such a way that there are frequent and durable interactions among specific individuals” (Welling and Kamann, 2001, p. 33).

3. Method

15 semi-structured in-depth interviews based on open-ended questions were conducted during the beginning of 2011 by the first author. Of the 15 respondents, six were site managers from contractors and nine were foremen (or in equal position) from the subcontractors. These roles were chosen since they are active in the procurement of subcontractors to the project, the ones who have the day-to-day contacts within the project and also are financially responsible for the business transaction. Due to the possibility that the involved parties’ opinions of the relationship might differ (e.g. Blois, 2002, Marchington and Vincent, 2004), both dyads of the exchange relationships were interviewed.

During the interviews, the site managers were asked about their current project, the subcontractors in their current project as well as questions related to their relationships to two specific subcontractors and their respective foremen. Each of the six site managers were asked to select one subcontractor in their current project which they desire working with in the future and one subcontractor which they do not desire working with in the future. Of the six site managers, three chose to not specify a subcontractor which they did not prefer working with in the future. The nine selected foremen were asked about their current project, their relationships to two specific site managers, one of which they desire to work with and one of which they do not desire to work with, as well as their relationship to the site manager who selected them for the study. Each interview lasted for approximately one and a half hour and was conducted at the respondent’s work site. All interviews were audio-recorded and transcribed verbatim. Notes were also taken during the interviews and reflections were summarized and noted after each interview. To corroborate the impressions from the interviews and to facilitate and enhance subsequent analyses, an additional interviewer accompanied during four of the interviews.

The six site managers work at three different regional construction firms in western Sweden, two at each contractor according to Table 1. Four of the projects were new buildings of which one partly is rebuilding. These projects were producing apartments. Two projects were pure rebuilding projects of which one was a hospital and one was offices. The size of the contracts was approximate numbers given by the site managers and ranged from 34 - 400 MSEK. Within each company a contact person recommended two or three site managers to interview. The criteria for these site managers were that they currently should be running a project with subcontractors involved and they should have been involved in the selection of the subcontractors. If three project managers were recommended, two were randomly selected for interviews.

Of the nine respondents at the subcontractors, eight had the official role as foreman, in several cases in tandem with other roles. One of the respondents, however, had the role as project manager. Nevertheless, when the respondent described his role as project manager, the similarities with the smaller companies’ foremen were many such as managing the contract and being the site manager’s contact during the project. The turnover of the subcontractors has ranged between ten and 65 MSEK with one exception at 1 745 MSEK and the number of employees ranged from eight to 53 with an exception with 1 200 employees as presented in Table 2.

Table 1. Site managers' current projects

Contractor	*Type of Site Manager's Current Project*		*App. Sum of Contract (SEK)*
A	*Senior apartments*	*New/rebuild*	*40 M*
A	*Apartments*	*New*	*34 M*
B	*Hospital*	*Rebuild*	*63 M*
B	*Offices*	*Rebuild*	*40 M*
C	*Apartments*	*New*	*270 M*
C	*Apartments*	*New*	*400 M*

Table 2. Subcontractor respondents' positions and company details

Representative's Position	*Profession*	*Turnover*	*Employees*
Owner, CEO and Foreman	*Painting*	*10 M*	*16*
CEO and Foreman	*Waterproofing*	*60 M*	*21*
Owner and Foreman	*Landscaping*	*18 M*	*8*
Owner, CEO and Foreman	*Casting*	*60 M*	*26*
Owner, CEO and Foreman	*Ventilation*	*35 M*	*18*
CEO and Foreman	*Demolition*	*30 M*	*17*
Foreman	*Painting*	*30 M*	*40*
Owner, CEO and Foreman	*Smithery*	*65 M*	*53*
Project manager	*Prefab concrete*	*1 745 M*	*1 200*

4. How site managers reproduce desired exchange relationships

During the interviews several themes crystallised. First in this section, the site managers' views on what makes certain subcontractors better than others is presented. Secondly, the importance of the specific individual in the role of foreman is treated. Last, the site managers' views on the price as a driver during procurement are handled.

A positive trait that the site managers point out with subcontractors is that they are positive and do not see any problems. One of site manager describes his own day by saying "it is always problems on every little thing. For me, my whole day is filled with problem-solving". It is hence argued as relieving when the subcontractor manages the problems themselves. What site managers are after is that the subcontractors should be self-propelled and creative. All subcontractors, however, are not supposed to be creative. Dependent on the trade, site managers expect a certain amount of creativity. Carpet layers for instance are not considered as needed to be creative while installation workers are. Additionally, the extra finish that some specific workers put to their work is highly appreciated. The additional costs which comes from the extra finish and the problem-solving, is according to the site managers, not a big problem since they argue that it should be more expensive to go back later on and fix the problems. Nevertheless, when too many hours are taken account for by the workers, the site manager has to take this up for discussion with the foreman. The site managers argue the extra costs to be a situation of giving and taking.

Another feature is to what extent the subcontractor keeps to the schedule. Since the schedule is argued by the site managers as the most important management tool during the production, it is considered essential to stick to it, whatever happens. For the subcontractor's account, it is the foreman's responsibility to manage their resources in order for the schedule to be followed. This might imply working longer days or dedicating more workers to the project in case the subcontractor falls behind the schedule. The site managers also discuss the deliveries of documentation concerning quality and environment as a variable when considering subcontractors. A site manager points out that some foremen deliver these documents by default while the site manager in other cases needs to pursue the foreman in order to get the documentation. The specific site manager argues that smaller companies in general not are as good as larger companies in these issues. "Some smaller companies do not know what to deliver – then I have to help them and this takes time", the site manager states and accentuates the general problem that the site managers come down to, their time. If the subcontractor does not deliver what it is supposed to, the site manager has to take time to get the subcontractor to deliver, whether it is documentation or project deliverables.

One of the site managers thinks that the firm is the most important when procuring subcontractors. He argues that "if you find a good company, then it is generally that everyone within the company is good, but there are exceptions“. The other site managers, however, consider the specific individual as decisive rather than the name of the company. "It is usually the foreman who is the company, so to speak; it is they who make it work", another site manager states. The site manager tells about the foreman at the pipefitter within his current project who formerly was employed by another firm. "Well, it was just like the old firm. It is the same actually, because he is the one who manages it", the site manager comments the foreman's change of firm. The reasoning points toward the importance of the specific individual in the role as foreman. This also argues against formation of long-term contracts with subcontractors since it not is possible to sign these contracts related to specific individuals. If the performance in the exchange relationship is dependent on a specific individual, the forming of firm-specific long-term contracts would be directly counter-productive.

The site managers also discuss the impact of the price during the procurement. One of the site managers was part of the procurement of a subcontractor which in the case was a landscaping subcontractor. Two firms had similar prices but the site manager chose this one since he had been working with the foreman before and he had good experiences. He had no experience from the other firm. He, however, expresses relieve that the preferred subcontractor lowered its price in the end of the negotiation since it was priced too high in the beginning. If this had not been the case, he might have been to use the other firm. The problem, the site manager states, is “since I had never worked with him [the foreman] before, I could not claim that he was worthless”. He continues, “If I had worked with him and had many bad experiences and failed jobs, then, maybe, I could have justified taking the more expensive company, otherwise it would have been very difficult”. This situation clearly shows how the price is the decisive factor in the selection of subcontractors. Even though the site manager had good experiences from a subcontractor, it is expressed as very challenging to procure it if the price is not the lowest. In order to deviate from the lowest price the site managers have to prove that the alternatives have performed very bad, not just that their preferred alternative have performed well in the past. On the question whether it ever is possible to procure a subcontractor which does not have the lowest price, the site managers’ answers simply is “No”.

5. How subcontractors’ foremen reproduce desired exchange relationships

The findings from the interviews with the foremen from the subcontractors mainly concern three themes. Firstly, the characteristics of a desired site manager are presented. Secondly, the management of additional costs during the project is discussed followed by the additional costs related to specific site managers.

One of the foremen states that most of the site managers that he has been working with over the years have been quite good. The common view of a desired site manager is a good leader and that the site manager gives good directives to the foremen. Being a good leader is pointed out as having control on everything and that the site manager is calm and to the point. In giving good directives it is not only included that the site manager gives directives of what to do the next day or next week, it also has to have the prerequisites in order for the subcontractor to be able to do the intended work at that point. Also the interdependencies with other subcontractors and the site manager’s responsibility to coordinate this, is mentioned as a major indicator when characterising a desired site manager. A foreman tells that his casting is dependent on that the ground subcontractor has finished the landscaping before he can begin and that the pipefitters are ready to put the pipes in the concrete before he closes the formwork for instance. Additionally, it was argued that with a site manager who manages to create a good atmosphere at the building site, the subcontractors’ workers do a better job.

A foreman of a landscaping subcontractor tells that he always makes a call to the site manager a few days before his workers are going to come to the site and do their work. During this call he ensures that the prerequisites are the right ones for his workers to perform a good work. If not, he clearly tells the site manager that they are not going to show up until the prerequisites are right. The prerequisites concern for instance that there are sufficient areas available in order for the subcontractor’s workers to do an effective job. “It costs me money to stand around and wait and I do not have that in my calculation”, the foreman states. “These trouble hubbies”, he says and refers to the site managers who do not have the prerequisites in place, “they want me to fix and tricks in order to do my work, but who is going to pay for it”. The foreman consider it better to take the discussion of potential additional costs before entering the site and doing the work in order to avoid an economic discussion in the end.

Another foreman, however, states that it might be a sensitive issue to take these additional costs up for discussion. He argues that the site manager might consider the foreman as expensive and difficult to work with and consequently do not want to work with the foreman in the future. This might be even if the additional costs, according to the foreman, are legit and accounted for. In the end, the foremen claim that the site manager is the one person who determines the profitability of the project from the subcontractor's perspective. "We notice a great difference between different contractors and their site managers", a foreman states.

That the specific site managers are decisive for the subcontractors' profitability and also the final pricing of the quotation is a unison view of the foremen. "Working with certain site managers takes longer time; you have to think of that", the site manager points out and argues that the mark-up on the pricing is not changed due to site manager but the unit times are. Another foreman, however, use a mark-up for certain site managers since he knows that he will get additional costs and that he will not get paid for these during the economic discussions afterwards. In the same way the foremen argue that site managers with whom they have previously worked and gained good experiences may get a lower price since the foremen knows that prerequisite are in place and sound economic discussions are conducted. The foremen also argue that it might take one or two projects together with a site manager in order to learn how they are working and also for the site manager to get to know the demands from the subcontractor. With the successful previous experiences, one of the foremen also states that the amount of requests for quotation increases from that specific contractor.

6. Discussion

Findings indicate that the individuals within both dyads of the exchange relationship play an important role in the outcome of the project and the specific relationship. Despite this, the procurement of subcontractors tend to be based on lowest bid while matching of individuals is given little or none consideration. If a discussion about the external integration of subcontractors is supposed to be valid, account is needed to be taken to the involved individuals. The current literature on supply chain integration within construction, however, seems to neglect this and focus solely on the inter-firm perspectives. When studying the practical situation of how site managers and subcontractors' foremen characterise and reproduce their exchange relationships, it seems to come down to individuals. The site managers, however, consider it a difficult task to take account to the specific individuals during the formation of the organisation since the current procurement processes within the construction industry and based in a firm-to-firm mind-set. It is, however, of interest to discuss how these identified characteristics, which in many cases are individual specific, may be considered in the procurement of subcontractors.

The market of subcontracting has earlier been argued as characterised to be short-term and incused as highly competitive and price-driven. Even though the aim of the exchange relationships between contractors and subcontractors might not be to fully integrate the supplier, the tough competitive procurement processes hinders potential benefits which are identified by site managers and subcontractors' foremen which have developed a mutual understanding of each other and each other's ways of working. In the shadow of the price-driven market it seems, however, as site managers as well as the subcontractors' foremen have identified this potential mutual development and the potential gains. In accordance with the findings of Bryman et al. (1987), the phenomenon where the desired subcontractors are asked by the contractor to recalculate their quotation in order for the contractor to be able to select them for the contract is a sign of this. Similarities might here be seen with the reasoning on coopetition as an procurement procedure in-between those of competition and cooperation (Eriksson, 2008).

Even though the organisational forces of the contractor tend to force the individuals toward a price-driven focus, the individuals themselves seem to pull the exchange relationship approach closer to collaboration than competition. Hence, the governance structure could be argued to look like market governance at organisational level which is pulled towards a quasi-firm or even a joint venture at individual level since the potential gains of prior beneficial collaboration seem to be highly valued by the involved individuals, given their ways of acting. Since the exchange relationships seems to be based in the interconnectedness of two specific individuals, such as the site manager and the subcontractor's foreman, long-term contracts could be directly counter-productive if these are firm-based as underpinned in much of the supply chain integration literature.

The competitive characteristics between the contractor and subcontractor in the procurement, however, seem to make it difficult for the site managers and foremen to actually take advantage of their mutual experiences which they have identified and developed through a common past. Furthermore, the narrow focus from the contractor's to lower the offered prices from the subcontractors, severely hinders subcontractors to invest in further development. Development, which later could have favoured the contractor through more effective working processes and a decreased cost structure. Following the reasoning by Marchington and Vincent (2004), it is difficult and unlikely for individuals in operational to initiate collaborative approaches towards external actors unless they have the support from the company. In this paper, however, it is argued that the opposite relationship also exists; company level exchange relationship is based in developed and refined exchange relationships at interpersonal level.

Consideration, though, has to be taken to the characteristics of the subcontractors as mainly small companies and their geographically limited spread. Their personnel resources may not make it feasible to geographically expand, why contractors would have to adapt their procurement processes to such features. The local geography and limited size, however, bring certain positive traits when considering the dyadic exchange relationships. In accordance with the reasoning of Bröchner et al. (2002), the regional characteristics entails that individuals tend to meet at recurrent basis and also know each other personally. If these traits of were to be realised during the procurement, a step would be taken towards the matching of specific individuals as recommended by Welling and Kamann (2001) as a mean to stimulate cooperation and more efficiently manage exchange relationships between contractor and subcontractors. Leveraging of these potential advantages during the procurement, however, seems to be absent.

7. Conclusions

With the aim to answer how dyadic exchange relationships are produced and reproduced by investigating how site managers and subcontractors' foremen characterise desired exchange relationships, 15 interviews with site managers from the contractors and foremen from the subcontractors were conducted. Even though the subcontractor market is argued as price-driven on an organisational level, the individuals within this study tend to strive towards collaborative exchange relationships with individuals with whom they have mutual positive experiences. By giving their preferred counterparts possibilities to recalculate their quotations in order to achieve the lowest price and by increasing unit times and mark-ups for non-preferred ditto, the site managers and subcontractors' foremen bypass the price-driven procurement approaches.

By narrowing the range of procured subcontractors and focusing on the use of core teams based on matching of individuals within the teams, a potential improvement in the construction supply chain can hereby be seen. Even though the gains of mutual experiences over time are clarified by both site managers and subcontractors' foremen, little is currently done in order to incorporate these insights in the procurement processes at organisational level as well as in the construction supply chain literature. Due to the situation where an organisational price-focus triumph over mutually established, well working processes in the exchange relationships between the site manager and foreman of the subcontractors, development and refinement of efficient mutual processes is hampered. This would, however, imply a need for support from the organisational level, in this case the top management. By changing the focus of the concurrent research within construction management from organisational level towards interpersonal level, new perspectives may also be elucidated concerning how firms within the construction industry interact and why. These questions serve as interesting areas for further research.

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Innovating ‘Assimilation Process’: The role of client leadership in fostering effective information flows in construction project supply chains

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Abstract

The effects of the cultural and structural fragmentation normally inherent in construction project teams, can be offset to a large extent, by effective communications. However for this to happen, it is first necessary to understand the detailed context that a particular project provides, before those communication channels can be optimised and the use of a supply chain model – in this case Lambert and Cooper (2000) – can provide the mechanism for developing this understanding. Issues of commercial motivation, information needs and specific requirements of effective communication channels can be analysed and understood from each participant's perspective. This paper details the implementation of such an approach within a single case study of a distribution warehouse for an experienced major client engaging with six other key project participants. It utilises ethnographic interviews combined with thematic analysis and abstraction, and finds that the client's role in managing informal information flows within the project supply chain, was critical to project success. Specifically, the client’s role was pivotal in cementing together positive working relationships across the first tier of the project team: this proactive activity that established the assimilation of all parties into a shared understanding is entitled 'Assimilation Process'. It is argued that clients trigger innovative informal processes through ‘Assimilation process’.

Keywords: Information flow, governance, formality, informality, supply-chain process links

1. Introduction

The information fragmentation in construction project organisations is claimed to have drastic impact on project performance. Although this can be attributed to a number of contextual issues, the industry’s structure, culture and lack of interest in technological innovation are identified to be the root factors (NAO 2001). The loosely coupled nature of the construction project supply chains contributes to the fragmentation of its operations (Dubois and Gadde, 2002). It is argued that fostering appropriate information flows, through innovative technological uptake, process improvement and cultural transformation, have potential to reduce the impact of structural fragmentation on project performance. However the counter argument is, that structural fragmentation in itself, is a hindrance to implementing new initiatives or making any progressive changes.

Information flows in construction projects can be explored through a number of theoretical contexts including supply chains (Jharkharia & Shanker 2005), project organization and knowledge/learning management (Egbu and Botterill 2002). Whilst each of these theoretical contexts is intricately interconnected, each provides a distinct theoretical lens to explore issues that influence information flows. Due to the fact that ‘information integration’ and ‘supply chain integration’ are theoretically intertwined, both seeking to improve the flow of information in any production system, this paper adopts the supply chain context to study the information flows. The testimony of the links between the above two concepts are evident through the innovative use of Information and Communication Technology (ICT) progressing from ‘automation’ to ‘organization wide ICT integration’ to ‘supply chain wide ICT integration’.

The ICT enablement of supply chains is critical for a high degree of coordination within the supply chain as it facilitates frequent and automatic flow of information (Donk 2008). The effective flow of information, in both ICT and supply chain literature, is discussed using the term ‘Integration’. Tan (2001) suggests that a “well integrated supply chain involves coordinating the flow of material and information, between suppliers, manufactures and customers” (p, 44). The current phase of technological advancement (Power 2005) can assist in creating virtual supply chains, where information flows seamlessly and efficiently between the members of the chain. Therefore, considering ICT integration via supply chain context, provides a meaningful way to conceptualise information management.

In essence, effective information and communication flows, both upstream and downstream, is the major facilitator of integration of people and process in supply chains (Smart 2008). The aim of this paper is, to explore the links between construction project supply chain members in fostering information flows in project organisations, through supply chain context. The paper uses Lambert and Cooper’s (2000) supply chain conceptualisation, which allows visualising the members of a project team through network of connections, to explore information flows. The case study was based on a distribution centre project for a retail supermarket chain procured through construction only procurement. The scope of work involved building work (including complex mechanical and electrical operations) with associated civil infrastructure work (e.g. access roads, drainage, sewerage).

2. Literature Review

2.1 Lambert and Cooper's model in the context of construction projects

Managing a supply chain is about maintaining effective flow of resources (including material, people and information) beyond the functional/corporate boundaries of firms. Shared business interests/goals/processes and effective information exchange between various business entities are essential to achieve this aim (Min & Zhou 2002). Mapping of a supply chain to visualise and identify any constraints on the information flows is a salient activity in administrating supply chains.

The supply chain model proposed by Lambert and Cooper (2000) used in this study, is due to its ability to depict numerous dimensions of supply chain operations, from an information integration perspective. Despite this model's inadequacy to represent additional layers of complexity arising from the transient network structure/relationships inherent in the construction project supply chains (London 2008), its ability to map multiple dimensions, justifies its use in the context of this study.

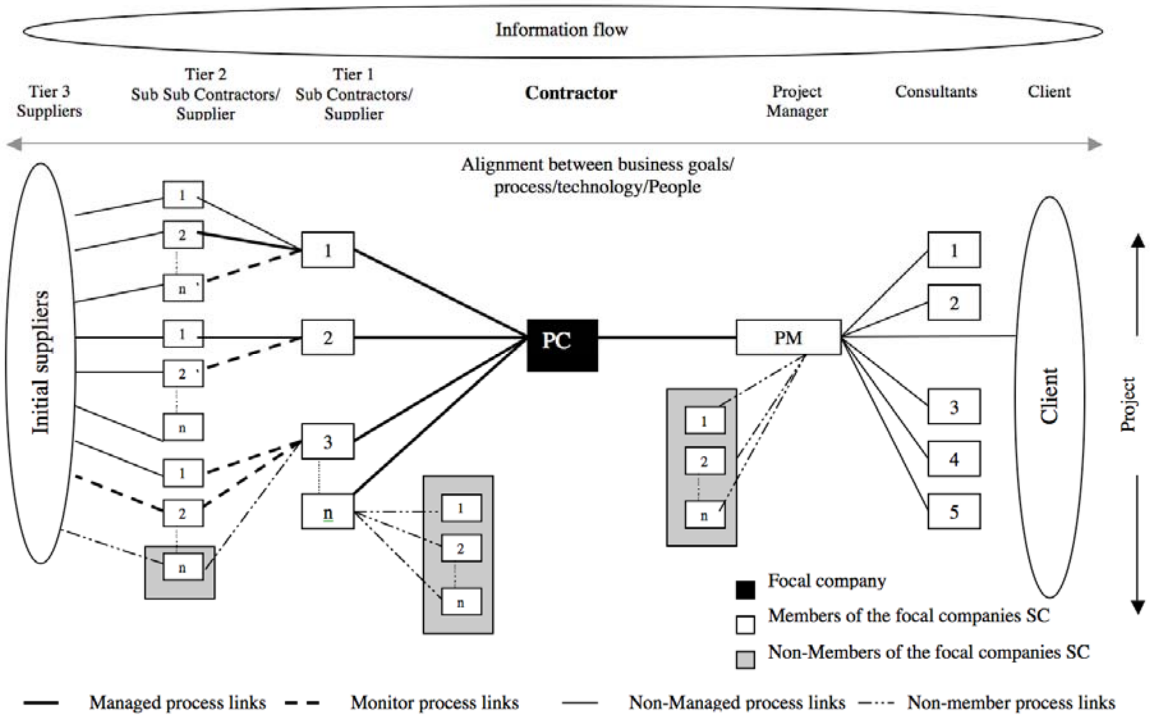

Figure 1: An illustration of Lambert and Cooper's (2000) model in the context of construction project

Figure 1, modified after Lambert and Cooper (2000) proposes a 'root and branch' model using a number of dimensions to aid the description, analysis and management of the supply chains. Conceptually it allows all members to be linked, from client to final supplier, in layers or tiers. It enables members to visualise and link various functions/aspects/operations within a firm and across firms. This assists in determining the different informational needs of supply chain members and how they should flow across the members. There are two explicit categories of links connecting the firms in the supply chain: (1) Contractual—legal—links and (2) Process—business/operational—links. The contractual links provide the legal basis for the connections between each member and their formal obligations to other members, including the provision of information flows. The process links are based on how the supply chain network connections are managed from an operational perspective. That is how firms should manage or monitor other members in the chain. The nature of the process links may or may not be influenced by the contractual links.

Figure 1 illustrates how the four types of Business Process Links (BPLs) can be used to reflect the supply chain relationships from a focal firm's point of view. The BPLs are classified based upon the degree of managerial interventions/relationships required to sustain effective supply chain operations. This model identifies a focus organization in a supply chain (in Figure 1 it is the principal contractor) to simulate how that organisation can/should manage supply chain relationships with other organisations in the project. Lambert and Cooper (2000) indicated that a complete management of all processes across all tiers of the supply chain, from a focus organisation's point of view, would be impractical. Therefore, firms need to design their interventions/relationships based on the needs of information and communication flows. The four business process links are discussed below in the context of construction project supply chains.

- Managed process links—links that the focal firm finds important to integrate and manage. This is to integrate the flow of resources, including people, money, plants and information. In the context of a construction project, depending on the governance approach, each firm will have a different extent of flow of resources between the members. As an example, from a principal contractor's (PC) point of view, it is unlikely that people, materials and plants need to flow between the PC and their upstream members (e.g. project managers and consultants). However, integration of information between upstream members as well as downstream members (e.g. sub contractors and suppliers) is fundamental for project success. Based on the operational arrangements, PC's and sub contractors may have flows of people, materials and other forms of resources between them.

- Monitored process links—links that are not as crucial to the focal firm. However, it remains important to the focal firm that these process links are integrated and managed appropriately between the other supply chain member firms. Monitoring the process links can be a formal requirement established through the governing mechanisms or it could be an informal activity. As an example, from a principal contractor's (PC) point of view, it is likely that the PC would like to keep trace on the resource flows between their sub contractors and their trading partners (e.g. labour sub contractors, material suppliers, etc). Although at times it may be outside their contractual obligations, to ensure smooth project operations, they may choose to monitor this informally.

- Not–managed process links—links that the focal firm is not actively involved with, nor are they critical enough to use resources for monitoring. However, the focal firm trusts other supply chain members to manage the BPL appropriately in ways that do not undermine the focal firm's goals. At times, firms may choose to opt out of monitored process links with some of the links to crucial firms and expect the trading partners will do the necessary management. As an example, from a principal contractor's (PC) point of view, the links between manufacturers of the air conditioning systems and the mechanical installation subcontractors, can be classified as a not-managed process link.

- Non-member process links—supply chains could be influenced by actions occurring in other connected supply chains. For example, a subcontractor to the focal firm could also be a subcontractor to one of their competitors, which could have implications on the focal firm's project. As an example, a link between a competitor principal contractor and a mechanical installation sub-contractor who works with a principal contractor (PC), can be classed as a non-member process link. The competitor principal contractor may benefit from conscious or unconscious divulging of intellectual property developed by the PC, by the mechanical sub contractor.

Identifying the type of process links between the firms could assist in establishing the extent of information flows between firms or vice versa. Mapping the process links can aid in identifying any weak links and information fragmentations across the supply chain.

2.2 Information flow via formalisation vs. informalisation

From a construction management perspective, Briscoe et al. (2004) suggest that supply chain integration is about information flow and systems alignment for collaboration. Information flows are an essential component for collaboration between supply chain members. Also, integration of supply chains needs to occur at both strategic and operational levels. Often project arrangements stress the importance of formal configurations of 'control oriented' mechanisms for 'engineering' information flows for collaboration between team members (Martinsuo and Ahola 2010). This approach may hinder genuine collaboration as it underplays the role of social dynamics and informalities on the development of relationships between team members (Bresnen and Marshall 2002).

So¨derlund (2010) argues that the temporary and fragmented nature of project organizations, often with a large number of new team members who enter the project at different points in time, poses significant challenges with establishing the interdependencies; therefore, effecting on managing process links. Depending on governance-based control may not secure true cooperation and information sharing among team members (Bresnen and Marshall 2002). In highly risky environments where uncertain transactions occur, formal 'market and hierarchy' based controls are not sufficient. Informal and collaborative forms of integration – including trust (Dainty et al 2001) and decentralized cooperation– are needed.

Overcoming the issues of conflict due to differing goals, resource scarcity, and interdependence of tasks, the project team should employ a project leader with strong brokering skills. These leaders can co-develop a clear project charter and use boundary objects for joint problem solving. They also should take to the role of making aware and constantly reminding about members the 'big picture' through open and balanced communication (Ruuska and Teigland 2009).

3. Research methodology

This research is underpinned by the ‘constructivist’ paradigm to accommodate the multiple realties of the world (Creswell and Clerk 2007), as construed by the different supply chain members. The constructivist paradigm enables analyse of diverse perspectives and experiences of the members of the project team arising from varying realities or multiple word views held by them. A single case study approach (Yin 2009) was employed to identify the boundaries of the project organisation. Data was collected using interviews contextualised in ethnographic principles (Spradley 1978). Seven individuals in key positions (client, project manager, principal contractor, architect, engineer, quantity surveyor and subcontractor) from the firm’s part of the project were interviewed. Following this stage, the interview data underwent a thematic analysis process to abstract the general themes displayed in the data. Abstractions were made linking the teams to arrive at the findings. The following section presents the abstracted themes arrived at via qualitative analysis process.

4. Results

4.1 Background to the case study

Case Study project is construction of a warehouse-distribution centre, procured through construction only method, for a large commercial retail chain entity in Australia. This project is part of a larger project encompassing the construction of a number (more than ten) distribution centres across Australia. The majority of the design team members in this project were and are involved in the construction of other warehouse-distribution centres. The contractor was selected through a competitive tendering process.

Client dictated the use of an online collaboration platform for document management and communication processes during both design and construction stages. The client incurred the cost associated with that initiative. All consultants and the principal contractor were mandated to use the platform while subcontractors were excluded from use. Most information transfer, including drawings, specifications and Request for Information (RFI), was conducted through the online platform. Each firm printed the relevant documents on a needs basis. Therefore, engagement with the online collaboration platform was limited to document transfer, including drawings and RFIs. Most information between the principal contractor and sub contractors was on paper, except for dealing with shop drawings. All parties also used email and telephone for communication.

The formal communications as dictated by the contractual links made (a) the project manager as the formal hub of information control between the consultants and the principal contractor (and their construction team) and (b) the principal contractor as the formal hub of information control between the construction team and the Project Manager (and the consultant team). However, the client emphasised the importance of fortnightly face-to-face site meetings and non contractual/non-formal communication between selected members of construction and consultant teams.

4.2 Ideologies and personalities shaping the project environment

The client representative (CR) for this project, also the representative to all other warehouse expansion projects, showed significant leadership in managing the project environment. CR had extensive delegated authority from the retail chain's CEO, providing CR with significant power position. CR used his power position to custom design governance mechanisms and communication protocols to suit each project in the expansion program. CR's pragmatic approach to problem solving and the desire to foster a collaborative project environment made him directly involved in the administration of the project organisation, to some extent, by passing the Project Manager. Client representative indicated that lack of certainty is the root cause for most problems arising in project organisation. Therefore CR focused on minimising uncertainty arising from their organisation. (A quote from the CR to reinforce this point).

> *Client Reprehensive: I guess [supermarket retail chain client] is a little bit different from other clients given that it is actively involved, tries to be as decisive as it can, because one of the worst things that you can have on the project is uncertainty . . . You have to create certainty. And my job is to create this certainty as well as stem the crap that comes out of (Client Board) sort of— [We use].. information management to create [some level of information flow] certainty.*

However, both client and sub contractor did not believe that depending entirely on the computer based information management systems, is the answer for effective information management. They see face-to-face communication as a critical component of information management.

> *Client Reprehensive: You can't [replace fact to face meetings with ICT tools], you can't. Because again you are creating a new project in its own right, a new team, and new set of relationships every time. You are dealing with guys who are very intelligent and very clever and very clinical right down to the other end, with the shovel. Now I walk out there and I go right up to the guys shovelling concrete and asked him how he is going. So you can't, you can't lose that. This is information management, that's all that is. This is not going to build the building, the guy at the other end is going to build it. This is information management to create certainty.*

The client indicated that it is important to acknowledge that, in a construct only procurement, the dynamics and communication between the firms change when the contracting team becomes part of the project. This change of dynamics in the project organisation shows the cultural divide between the client/consultant team and construction team. This arises of the lack of trust between both teams on the intention of the other.

> *Client Representative: The builder wants to get as many extensions as he can to limit his risk of being clobbered for damages. The client wants no extensions as it puts some skin in the game for the builder—that's fine, that process goes on, it's just a side process.*

Client believed in developing collaboration between project team members through shared understanding to achieve common goals. However, in projects governed by construct-only procurement, connections between most firms are treated as isolated contracts. This does not give each firm the overall picture of the project from the inception. This occurs due to the nature of project operations, which takes place in stages. Therefore, client believes that in a construct only setup, establishing common goals for a project complementing the goals of individual firms, is important. Even more important is communicating strategies that may enable such alignment of goals to all the project team embers. Subsequently, firms in a project need to be informed about how their firm will fit into the overall project and with other firms.

Client Representative: So what we do is we have what we call Day 1 meetings where we invite everyone involved with the project and we lay the project out to them. Key subcontractors, the builders, all the people. And it has two purposes. One is to explain the project to everyone that is going to work on it—you know, if you are going to work on something you need to know why you are doing it. So we tell on why we are doing it. We're not just building a building, this is why we are doing it, this is what it looks like, and here is the things to watch.

Common goals are not purely about completing the project within time cost and quality, but could also be to foster a fairness-based project environment to ensure that individual firms in the project are not unfairly financially hurt.

Client Representative: Sure, we have a contract, and there is a commercial arrangement but, you know, provided everyone works together and everyone makes a little book of money and everyone is happy and we get our building and it is not a disaster. You end up with a success . . . And then the other thing that we engender in this day 1 meeting is that it is a two way street. It is a "we" team, right? It is "us", "US" doing the job. It is not just you and you doing it for me, it is I'm helping you and you are helping me . . . this all sounds very wankie but this is what we do.

4.3 Beyond the contractual links: Fostering informal information flows

Most of the project team members *believed* that communicating outside the formal or contractual lines of communication, in order to develop collaboration, could open up disputes. Project Manager believes that although they espouse a friendly and informal relationship-based approach to project management, contractual obligation can only be enforced via formal mechanisms. However, CR *believed* that some form of informal communication between the project team members is critical for effective project operations. The formal contractual arrangement did not provide the means to foster the kind of communication client espoused, as the principal contractor employed large number of team members, as sub contractors. Tensions between these two beliefs were suppressed by the client's power position. That is, the client representative was bestowed with the power to engender informal links between the team members, bypassing the formal lines of communication stipulated in the contracts.

Project Manager: Obviously, it is relationship based, but when we need to we do look at the contracts and see that they are fulfilling the contractual obligations to the client if that supplier is not obliging by doing those tasks we can ask once, asked twice, but we do have a contract we can *use to say to them that they have to perform this, this, and this within this time, and within this cost.*

Client Representative: We get relationships going between the fire consultant and the fire subcontractor and the services manager of the builder. So we deliberately do those introductions. The fire consultant and the fire subcontractor, and they walk through the plans and the consultant will explain his design, what is this, what is that. The engineer will do the same with the structural steel guy and concreter, and so it goes on, electrical, and then you get these little relationships going. And then the other thing that we engender in this Day 1 meeting it is a two-way street.

The client engendered collaboration by introducing initiatives away from the formal mechanisms to exploit ‘project drawings’ and the ‘construction program’ as boundary objects.

CR: [I tell the project team that] we have to continue with the process outlined in the contract. I say as part of you working with me—we have to be transparent on your target program. The contractual tool we use, but at the same time we are all driving hard at the target program. We understand that the target program is not contractual but it is the target.

The fostering of ‘informal relationship and communication’ between non-contractual parties, a client lead innovative approach, cannot be explained via the supply chain process links described by Lambert and Cooper (2000). The idea of ‘Assimilation Process’ allows carefully designed informal communication in a project complementing the formal mechanisms. The CR, once the assimilation was fostered between key members, did not explicitly monitor the links between them. However CR expected the project manager to use the existing Managed Process Links to identify any contradicting outcomes arising from the assimilation process with the formal expectations (e.g. cost over runs).

Figure 2 maps the ‘supply chain process links’ from the client’s position. Although the client has contractual links with the project manager, architect, engineer, quantity surveyor, and principal contractor, the client only managed the process link with the project manager. However, the client monitored the link between the other firms e.g. project manager and architect, architect and principal contractor etc. However, the ‘Assimilation process’ (AP) fostered by clients created direct communication between the consultants and subcontractors in the areas of mechanical, electrical and firer, and also the principal with the architect, fostering a collaborative work environment to solve problems as and when they arose.

The Project Manager’s only contractual link was with the client. However the Project Manager, managing the project on behalf of the client, required development of ‘Managed Process Links’ with the consultants (e.g. architect, engineer, quantity surveyor, principal contractor) and the client. The rest of the supply chain links from the Project Manager’s point of view was characterised as ‘non-managed links’. PM’s attitude favouring formal approach to management, did not allow them to foster assimilation process between non-contractual parties. However, PM’s position was complementary to client’s position, as the PM ensured that the supply chain members fulfilled their formal obligations as part of their contracts and did not exploit any situation arising out of the assimilation process.

The Principal Contractor had contractual links with the client and their sub-contractors. The Principal Contractor was the formal conduit for information flow between the consultants and the sub-contractor via the Project Manager. The Principal Contractor, as the leader of the construction team, monitored links between the subcontractors and client team. However, in this project the Principal Contractor also developed assimilation processes with the consultants that were fostered by the client. This enabled reducing the time taken to clarify the required information to construct the building.

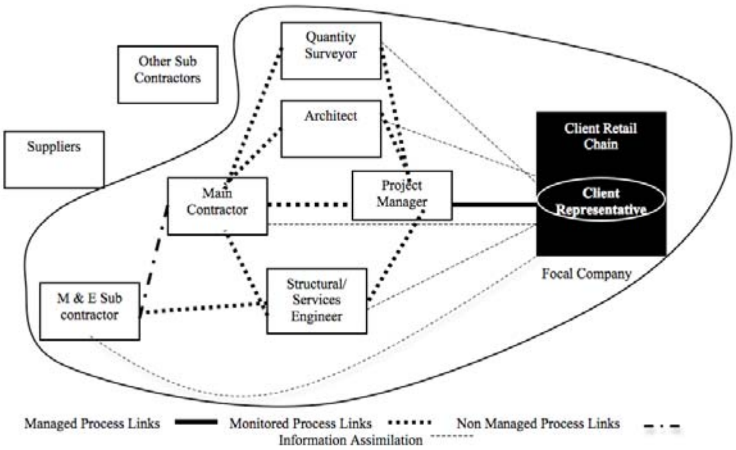

Figure 2: Supply chain map with 'Process links' mapped from client's focus

The reflections on the project progress from the interviewees indicated that this project was somewhat different to the other projects they had been involved with in the past. They acknowledge the positive attitude of the client and the role of the CR's leadership in contributing to this environment.

Principal Contractor: [This project is] very collaborative. It's certainly what (clients name) and (clients representative) have emphasised from day one. And on day one all of the parties sat around the meeting table here onsite and (the clients representative) said 'we are all a team, we [are] working as one, to achieve the same goal'. So he was very much driving that "we are a team" philosophy. He doesn't want to see any animosity, he doesn't want to see people squabbling, he wants us to get the job finished. And if people are working together, you know if people ask a question and the question is being responded to up on time, it helps the process. So everyone has a part to play, so let's help each other out. So that was the driving force behind (clients name).

In summary, results indicate the four process links, namely 'Managed Process Links', 'Monitored Process Links', 'Not Managed Process Links' and 'Non Member Process Links' are inadequate to capture the actual flows of information between the supply chain members in this project. Moreover, an innovative process termed 'Assimilation Process" was identified, that appeared critical to the effective operations. This link is purely related to information management between parties who are not contractually linked. The two node organisations associated through the assimilation processes are neither contractually linked nor fit into the process link proposed by Lambert and Copper (2000). Carefully designed Assimilation Processes made the flow of information between construction and consultant teams more effective, creating a harmonious project environment.

5. Discussion and conclusions

Managing the flow of information is one of the most critical facets of construction project supply chains. The findings of this study suggest that the clients, by prudently flexing their power position, can design formal and informal governance mechanisms that can foster effective information flows between supply chain members. Findings indicate that face-to-face interaction is essential to complement information technologies in managing information flows. The face-to-face communication is conducive for building relationships between supply chain members. These findings corroborate with Pant, Sethia and Bhandarib (2003) who noted that ICT has an important role in improving information flows, but that it is not as simple as installing ICT hardware and software.

It was evident that the client's understanding of the contextual challenges in managing temporary and fragmented project organisations as descried by So¨derlund (2010), enables client's and their representatives, to devise appropriate strategies to manage the project pragmatically. The client's approach to creating certainty wherever possible, by using formal 'market and hierarchy' and informal mechanisms to mange highly risky environment and uncertain transactions, is discussed in the literature (Bresnen and Marshall 2002).

The client taking the project leadership role with strong brokering skills can enable them to co-develop a clear project charter and use boundary objects for joint problem solving. The construction program and construction drawing can be used as boundary objects to foster relationships and collaboration between members. Clients assume the role of constantly reminding the project team members about the common goals and the strategies that are in place to achieve them. These findings strike accord with Ruuska and Teigland (2009). Although triggering 'Assimilation Process' appears to be a simple process, innovation based on informal communication, it needs to be carefully orchestrated at appropriate junctures to suit each project context.

Essentially, findings indicate that clients assuming a leadership role with a fine appreciation of the project environment, can engender innovative initiatives that can improve the project outcomes. Specifically, they can design governance by mixing both formal and informal mechanisms to complement each other, in creating a project environment conducive for effective information flows.

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Collaboration between Architects and Contractors in Former Japanese Building Construction Projects

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Abstract

Collaboration between design and construction is widely required to confirm building qualities. In the West, project delivery systems vary intending collaboration between design and construction. On the other hand, people in Japanese projects have traditionally had a collaborating relationship between design and construction such as the design-build process. We aim to consider the background, purposes, factors and methods of such collaboration between design and construction in Japan. In this way, this paper deals with two famous Japanese architects, Mayekawa Kunio and Togo Murano, who designed many projects in the middle of the twentieth century. Each of them collaborated with contractors in characteristic methods. Mayekawa Kunio's method is a good example of the "engineering collaboration method," and Murano Togo's method is a good example of the "architectural collaboration method." We examine two of their real projects based on interviews and related documents and drawings, and then, show their methods of collaboration between architects and contractors.

Keywords: architects, contractors, collaboration, sharing roles and responsibilities, building construction process

1. Introduction

Traditionally, collaboration between design and construction has been an important aspect of Japanese building construction projects. However, professional specialization and the strictness of the legal system have brought about a significant change in this relationship. Therefore, we aim to consider the background, purposes, factors, and methods of such traditional collaboration between design and construction in Japan. To this end, this paper shows the actual conditions of collaboration between architects and contractors in former Japanese building construction projects. We examine how architects and contractors shared roles and responsibilities and, during the building construction process, communicated with each other through analysis of two real former projects. As mentioned in the next chapter, these issues vary across projects according to the objects of collaboration.

Furthermore, if we examine the above issues in the context of modern-day Japanese building construction projects, it appears that these issues vary according to not only the objects of collaboration but also to the kind of organization to which an architect or an engineer belongs to and the time at which they join a project. In Japan, some large design firms employ both architects and engineers, while many other design firms employ either architects or engineers. Furthermore, many general contractors have in-house design teams, employing many “Kentikushi”s and engineers permanently. (“Kentikushi” is a government-recognized qualification of designers in Japan and means “architects and building engineers.”) If architects and engineers work for the same design firm, they may start collaborating with each other at an early stage in project. Architects and engineers in the in-house design teams of general contractors may also collaborate with construction engineers in the design stage. However, if the architects and engineers belong to separate organizations, how do they communicate with the architects and engineers of other organizations? In the case of no communication, what problems occur with regard to the quality confirmation of buildings?

2. Research Framework

2.1 Two Typical Collaboration Methods

In building construction projects, the architects responsible for the architectural design collaborate with structural and environmental engineers. Therefore, these architects and engineers constitute the “design team.” Furthermore, many Japanese general contractors have in-house design teams such as the above, employing many architects and engineers permanently. General contractors also employ engineers who are in charge of site work management, as done in the Western system. Furthermore, special contractors employ engineers who participate in the design process. Therefore, these architects and engineers, employed by general contractors and special contractors, constitute the “construction team.” By the above, we assume two models as typical methods of collaboration between architects and contractors in Japan (Fig. 1). In the first method, architects participate in much of the construction process compared to the usual. In the second, contractors participate in much of the design process.

Collaboration methods of architects and contractors are categorized as method 1 and 2 according to their design contents, which are the objects of collaboration. In method 1, architects are more concerned with the engineering quality than with the scope of service generally assumed. Engineering quality is the main purpose of engineering design, which includes the safety of buildings, functionality, and constructability. Therefore, we call method 1 the "engineering collaboration method." In method 2, contractors are more concerned with the architectural quality than with the scope of service generally assumed. Architectural quality is the main purpose of architectural design, which includes the form and concept of buildings. Therefore, we call method 2 the "architectural collaboration method."

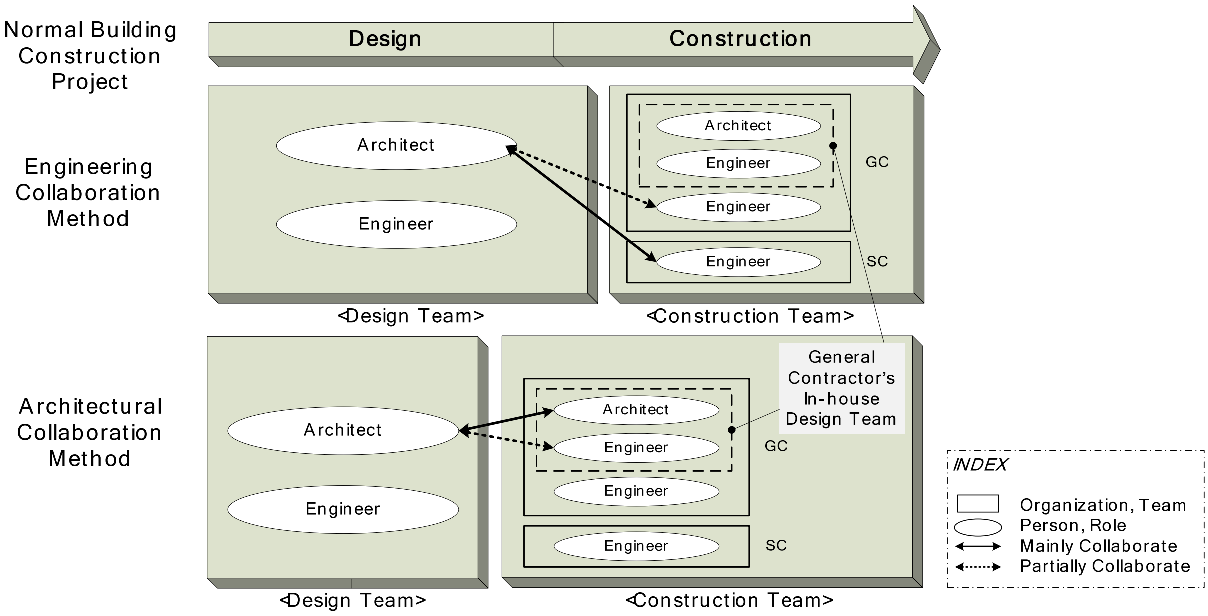

Figure 1: Typical Methods of Collaboration between Architects and Contractors in Japan

Stating in detail, in method 1, architects mainly collaborate with the engineers employed by special contractors and partly collaborate with the site work management staff of general contractors. In the design-build process in Japan, contractors usually prepare shop drawings and fabrication drawings, prepare construction plans and books on construction essentials, and manage the site work. However, in this method, architects prepare detailed drawings near shop drawings and participate in the construction process, which includes preparing construction plans and books on construction essentials and manage the site work. Therefore, the design team collaborates with special contractors who actually execute work in the design stage. Moreover, the design team which is more concerned with design and construction takes charge of the adjustment of architects and contractors. On the other hand, in method 2, architects mainly collaborate with architects from the general contractors' in-house design team and partly collaborate with engineers of in-house design teams. In the design-bid-build process in Japan, contractors are usually selected after the design development is completed, and contractors do not participate in the design process before a tender is issued. However, in method 2, contractors are already selected at the beginning of the design process; they participate in preparing preliminary design drawings and working drawings. Following this, the contractors participate in the architectural design process, support embodiment of architects' intentions, and execute the engineering design in order to achieve design intentions. Thus, the design team collaborates with a general contractor, who draws up the construction plans and takes charge of the site work management, in the design stage. Moreover, the construction team (the general contractor's in-house design team), which is more concerned about the design and construction, takes charge of the adjustment of architects and contractors.

2.2 Research Methods

To study concretely, this paper deals with the real projects of two famous Japanese architects, Mayekawa Kunio (his method exemplifies the engineering collaboration method) and Murano Togo (his method exemplifies the architectural collaboration method). Following this, we consider the collaboration between architects and contractors from the following two viewpoints: "organizations and sharing of roles and responsibilities" and the "building construction process." We show the organizations that participated in each project, the relationship between the organizations, and the manner in which they share roles and responsibilities. Subsequently, we survey the collaboration in the building construction processes. We examine the Tokyo Metropolitan Art Museum and the Kyoto Takaragaike Prince Hotel, undertaken by Mayekawa and Murano respectively. We have chosen these projects for our study for two reasons: First, the preserved data on them are abundant and usable. Second, we can conduct sufficient number of interviews with the architects and contractors who were involved in the projects owing to their availability. Using the above, we closely examine the collaboration between architects and contractors.

3. Case 1: Project led by Mayekawa Kunio (Engineering Collaboration Method)

3.1 Overview of Object

Mayekawa Kunio (1905-1986) was one of a Japanese modernist architect. One of his characteristic design methods was the technological approach which aimed to promote the development and sharing of fundamental building technology and endorse stoic and fastidious plastic design. Consequently, through the collaboration with specialist contractors, Mayekawa's original tiled panels system, weatherability steel, and architectural precast concrete (PC) were developed. Mayekawa's original tiled panel system entails fixing tiles to forms before placing concrete and unifying them so as to prevent the tiles from falling.

The Tokyo Metropolitan Art Museum (1975) is a public art museum located in Ueno Park, Tokyo. The building elements involving close collaboration on design and construction are the structure of concrete, of which architectural concrete forms a part; the ceiling of architectural PC; the tile on the wall surface, which partly adopted Mayekawa's original tiled panel system; and the doors and windows, which partly used weatherability steel based on the technological approach.

3.2 Research Results

3.2.1 Organizations and Sharing of Roles and Responsibilities

The organizations that were involved in the Tokyo Metropolitan Art Museum project and the sharing of roles and responsibilities are mentioned below (Fig. 2).

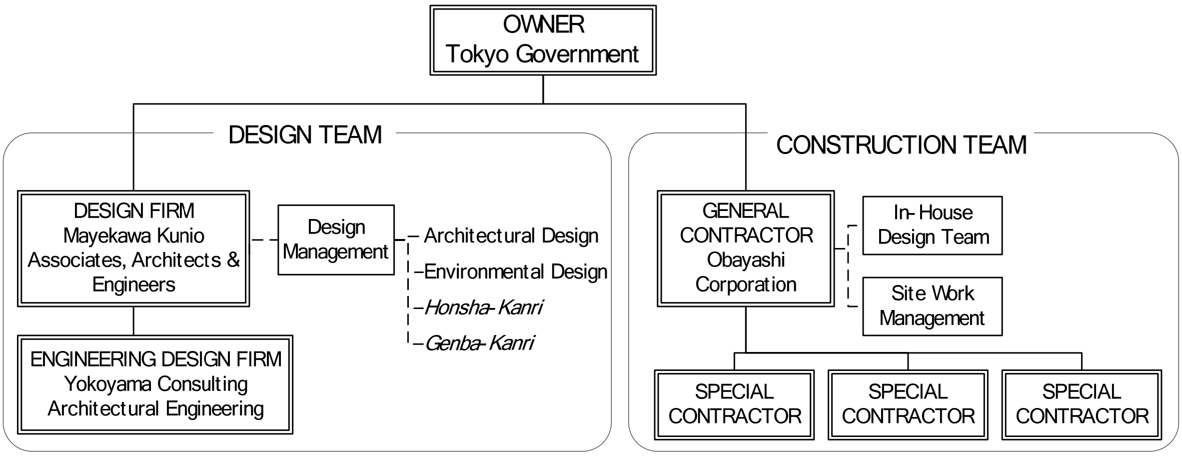

Figure 2: Organizations involved in the Tokyo Metropolitan Art Museum Building Construction Project

This project was commissioned by the Tokyo Metropolitan Government, the architect were from Mayekawa Kunio Associates, Architects & Engineers, and the general contractor was Obayashi Corporation.

Representatives of the Education Bureau of the Tokyo Metropolitan Government resided at the construction site permanently as the owners and participated in site meetings and approved design change.

Being a design firm, Mayekawa Kunio Associates, Architects & Engineers were responsible for the design management, architectural design, and environmental engineering. Mayekawa undertook the supervision. Furthermore, he inspected and gave directions around the construction site, and took the final decisions on important elements such as the arches of the sunken garden, sashes, and color arrangements. Yokoyama Consulting Architectural Engineers also participated in the project and took charge of structural engineering. In the construction stage, they carried out "Kanri" by dividing themselves into *Honsha-Kanri* and *Genba-Kanri*. *Honsha-Kanri* (in Japanese, "Honsha" means head office, and "Kanri" is a concept which includes "supervise" and "inspect") were in charge of the detailed design about unspecified parts, and of the design change in the design office. Two persons took charge of the *Honsha-Kanri*: one (A1) was responsible for the exchanges between Mayekawa and the *Genba-Kanri*, and the attendance in regular site meetings. The other (A2) was responsible for making drawings under A1's directions and for communicating with A1. The *Genba-Kanri* (in Japanese, "*Genba*" means construction site) permanently resided at the construction site and made arrangements with the owner; examined and approved shop drawings, books on construction essentials, and site work management plans; and issued site instructions. Two persons were in charge of the *Genba-Kanri*. One (A3) took charge of the exchanges between the owner and the *Honsha-Kanri*; managed the process of preparation of drawings in the design office so that they are appropriate for construction; gave instructions to contractors; and approved shop drawings. The other (A4) was responsible for collating drawings and executing work.

From Obayashi Corporation, approximately 30 were responsible for site work management. Moreover, a draftsman permanently resided at the construction site and made shop drawings. Specialist contractors signed the subcontract with Obayashi Corporation and participated in the project. Some of these contractors collaborated with the architects in the design stage.

3.2.2 Building Construction Process

The collaboration in the building construction process of the project is shown as follows (Fig.3).

In the schematic design stage, materials and construction methods that required collaboration with specific specialist contractors were chosen (for example, Mayekawa's original tiled panel system and architectural PC). Therefore, in the design development stage, specialist contractors participated in the examination of the details and constructability of these materials and forms. Moreover, the architects prepared details near shop drawings.

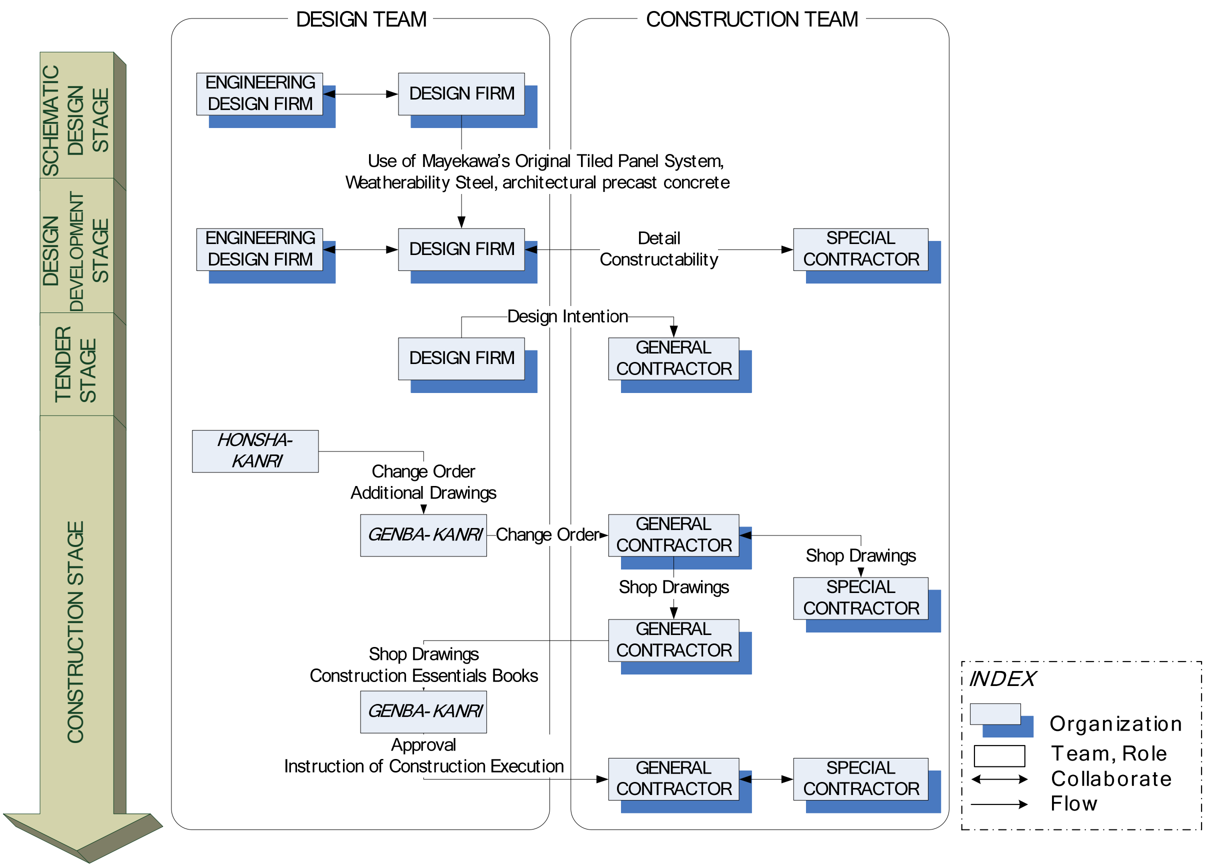

Figure 3: Building Construction Process of the Tokyo Metropolitan Art Museum Building Construction Project

From the tender stage to commencing the execution of the structural works, the architects explained the design intentions such as important design parts and cautionary measures to be taken during execution of work, to the site work management staff of Obayashi Corporation. Moreover, the architects showed the contractors the building in which Mayekawa's original tiled panel system was used in order to familiarize the contractors with this system.

In the construction stage, the owner and persons in charge of the *Genba-Kanri* and the site work management staff of the general contractor permanently resided at the construction site, so that anything that required examining could be addressed every day. The contents of the examination by *Genba-Kanri* persons and the site work management staff were reflected in the shop drawings and were shared. Moreover, regular site meetings about work progress, etc. were held once a week, and in which the owner, the *Honsha-Kanri* persons, the *Genba-Kanri* persons, and the site work management staff participated.

Instructions on design change from the owner, such as use of rooms, were transmitted to the *Genba-Kanri* persons with a change order. They informed the *Honsha-Kanri* persons about the changes and requested additional drawings. The *Genba-Kanri* persons explained the additional drawings to the owner and obtained informal consent. They then transmitted the information regarding the changes to the site work management staff.

When a draftsman of Obayashi Corporation and specialist contractor prepared the shop drawings, the *Genba-Kanri* persons evaluated “whether design intentions are correctly reflected in the shop drawings,” and approved the shop drawings. In some elements such as weatherability steel sashes, Mayekawa approved the shop drawings. In addition, the site work management staff checked whether the shop drawings made by specialist contractors suited the construction budget, and the *Genba-Kanri* persons approved them. Moreover, the site work management staff obtained the owner’s approval for important drawings, which cost a large amount of money, such as that of Mayekawa’s original tiled panel system.

The *Genba-Kanri* persons checked the books on construction essentials, which the contractors had summarized before the execution of the construction, regarding whether design intentions were achieved when the work was carried out. After the approval from the *Genba-Kanri* persons, the work could begin.

Furthermore, the *Genba-Kanri* persons supervised the placing of concrete. They checked staff charts of the site work management staff, the test results regarding forms, steel reinforcement, etc. that the specialist contractors had submitted. One day before placing concrete, the *Genba-Kanri* persons gathered the site work management staff and specialist contractors, and conducted a simulation in order to deepen contractor’s understanding of roles and responsibilities, procedures, and notes. On the day of laying concrete, the *Genba-Kanri* persons checked the time left for ready-mixed concrete and supervised the placing of concrete.

3.3 Collaboration between architects and contractors

From the above, the features of collaboration between the architects and contractors in the building construction project led by Mayekawa are as follows.

The first feature is that the specialist contractors participated in the examination of the characteristic design elements from the design stage, and the collaboration continued into the construction stage.

The second feature is that after architects showed their design intentions, they examined the construction and technology with the contractors (the general contractor and the specialist contractors). To achieve design intentions faithfully, both architects and contractors examined the shop drawings, books on construction essentials, and site work management plans and carried out shop inspection. Moreover, the *Genba-Kanri* persons conducted a simulation and supervised the construction execution of Mayekawa’s original tiled panel system and placing concrete.

The third feature is that the *Genba-Kanri* persons, who permanently resided at the construction site, played the role of adjusting and mediating communication between the *Honsha-Kanri* persons, the site work management staff, and specialist contractors. The *Genba-Kanri* persons informed the *Honsha-Kanri* persons regarding the determination matters at the construction site, and managed the process of making drawings in the design office. Furthermore, the *Genba-Kanri* persons informed the site work management staff about design change, checked whether design intentions were correctly reflected in the shop drawings, and approved them. They also approved books on construction essentials and site work management plans and issued written instructions.

4. Case 2: Project led by Murano Togo (Architectural Collaboration Method)

4.1 Overview of Object

Murano Togo (1891-1984) is also a Japanese modernist architect. He called the parts that he designed freely as per the owner’s requirements and design conditions “one percent of Murano”: he completely dedicated himself while designing the details of such parts.

The Kyoto Takaragaike Prince Hotel (1986, the present Grand Prince Hotel Kyoto) is located in Takaragaike in Northern Kyoto. The building elements involving close collaboration on design and construction are the outer walls of the low-layer building, on which natural stones were stuck on the three-dimensional phase; the ceiling and wall of banquet halls, which are the main parts of the hotel; and the window-sills, which form part of the characteristic design of the upper-layer building.

4.2 Research Results

4.2.1 Organization and Sharing of Roles and Responsibilities

The organizations that participated in the Kyoto Takaragaike Prince Hotel building construction project and sharing roles and responsibilities are as follows (Fig. 4).

The Kyoto Takaragaike Prince Hotel building construction project was commissioned by SEIBU Railway; the architects were from Murano & Mori Architects; and the general contractor was Takenaka Corporation. Takenaka Corporation also took charge of environmental engineering.

At the beginning, the project was to progress by the design-build process involving Takenaka Corporation. However, Murano & Mori Architects participated in the project as per the requirement of the owner, SEIBU Railway. Earlier, SEIBU Railway had requested Murano & Mori Architects to design the Prince Hakone (1978) and the Grand Prince Hotel New Takanawa (1982). In these projects, too, the general contractor was Takenaka Corporation.

Murano & Mori Architects took charge of the architectural design and structural engineering, and the staff prepared the drawings and scale models, as a design firm. Murano himself inspected the site, drew sketches, examined drawings and scale models, and arranged with the owner. A design chief from the design firm, who conceptualized almost all projects at Murano & Mori Architects, mediated the communication between Murano and the architects and assisted Murano. In the construction stage, for the *Zumen-Kanri*, five architects participated in the project from Murano & Mori Architects and resided at the construction site permanently. At Murano & Mori Architects, the staff called *Zumen-Kanri* (in Japanese, "*Zumen*" means drawings) took charge of preparing architectural drawings, making up a schedule of shop drawings and mockups and their examination, and approval and arrangements in the construction stage. An architect, who had resided permanently at the site of Grand Prince Hotel New Takanawa project, became the chief of the *Zumen-Kanri*. However, those in charge of architectural design and structural engineering remained in the office and prepared the drawings of unspecified parts as per the design chief's instructions.

From Takenaka Corporation, approximately ten architects, structural engineers, and environmental engineers, who belonged to the in-house design team of Takenaka Corporation, shared the design from the beginning of the project. Moreover, the chief of the in-house design team of the Grand Prince Hotel New Takanawa (henceforth the New Takanawa design chief) received Murano's offer and participated in the project. He grasped Murano's intentions and conveyed them to other architects and engineers in the in-house design team. In the construction stage, the site work management staff included a draftsman, architects, structural engineers, and the New Takanawa design chief of the in-house design team, who permanently resided at the construction site. They examined constructability and compatibility and then prepared detailed drawings. Moreover, they judged which parts of the building required time and money (because the owner might deem final performance important, or Murano & Mori Architects might design preponderantly), and which parts could be advanced rationally or should be decided earlier. Further, they managed cost distribution and progress of making drawings.

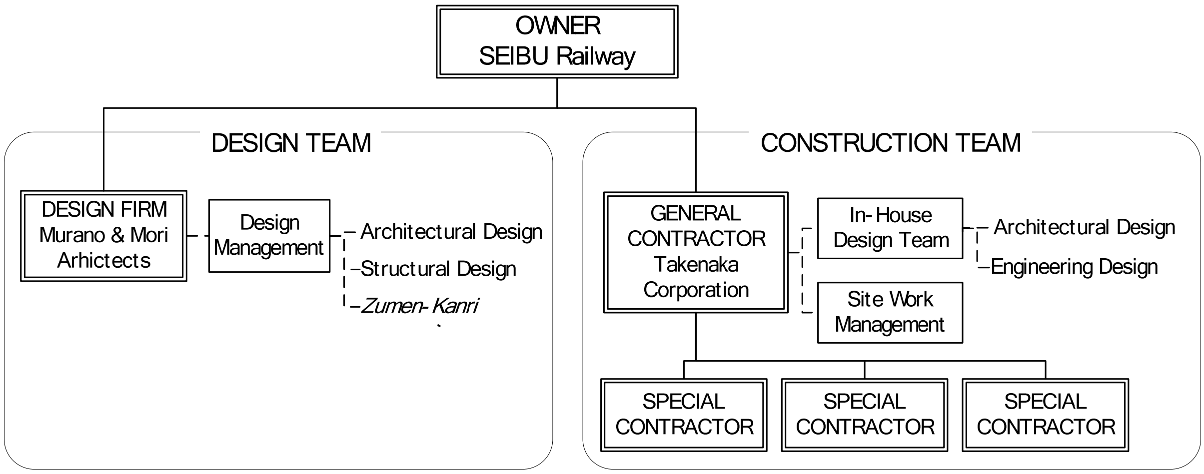

Figure 4: Organizations involved in the Kyoto Takaragaike Prince Hotel Building Construction Project

4.2.2 Building Construction Process

The collaboration in the building construction processes of the project is as follows (Fig.5).

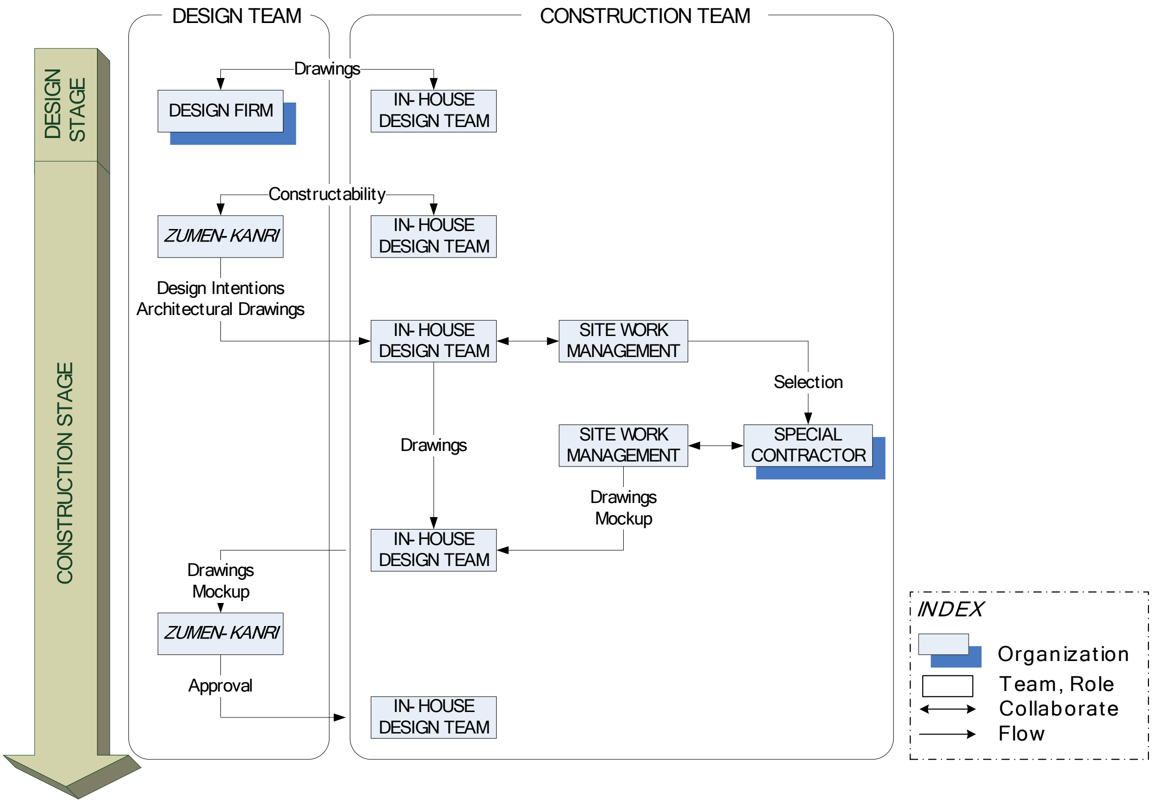

Figure 5: Building Construction Process of the Kyoto Takaragaike Prince Hotel Building Construction Project

In the design stage, Murano drew the sketches and the architects of Murano & Mori Architects prepared the drawings, which were drawn to scale but did not have dimension. Moreover, clay models were made and were corrected by Murano. The in-house design team of Takenaka Corporation understood these intentions, and they considered the design condition, examined construction methods and cost, and then prepared the drawings. Murano & Mori Architects corrected these drawings and also prepared the drawings. Such exchanges were repeated.

In the construction stage, the *Zumen-Kanri* persons of Murano & Mori Architects, the in-house design team of Takenaka Corporation, and site work management staff permanently resided at the construction site. Therefore, in addition to regular site meetings, they had site meetings almost every morning and at any instance of dispute.

In Murano & Mori Architects, under the design chief, they made drawings of the portions that were not examined sufficiently in the design stage and submitted them to the *Zumen-Kanr'* persons at the construction site. The *Zumen-Kanri* persons interpreted these drawings, put in characteristic details of Murano & Mori Architects, and then prepared the architectural drawings. At this time, they consulted with the in-house design team of Takenaka Corporation about constructability, if needed. The *Zumen-Kanri* persons sent the architectural drawings and conveyed design intentions to the architects of the in-house design team. They also showed them the details about forms and materials and explained to them how to use the materials (for example, the form of curves of eaves, and the curved surface of marble columns). The elements of buildings, which Murano & Mori Architects designed in the past, were frequently used for illustration. Regarding these, the in-house design team and the site work management staff of Takenaka Corporation examined the most rational methods according to the construction situation and selected an expert specialist contractor.

On the basis of the above examination, and in order to support the examination of parts that should be decided at an early stage, the in-house design team of Takenaka Corporation prepared the drawings (including full-size drawings). They also made structural drawings considering the joints and detailing, and adjusted shop drawings. The draftsman of the general contractor and specialist contractors prepared the shop drawings, and if required, made mockups. The in-house design team examined them to check whether they reflected design intentions and were achievable. Further, the *Zumen-Kanri* persons examined and edited them accordingly. The above exchange was repeated. The *Zumen-Kanri* persons approved using mock-ups and samples (for example, colors and texture, such as wood and paint materials) in addition to shop drawings. In the case of outer walls of the low-layer building, specialist contractors prepared full-size drawings on the floor of the outer walls of the low-layer building. They placed the actual sandstone material on them and examined the alignment of the stones. The *Zumen-Kanri* persons examined this as well.

4.2.3 Collaboration between architects and contractors

From the above, the features of collaboration between the architects and contractors in the building construction project led by Murano are as follows.

The first feature is the organization of architects and contractors. The in-house design team of the general contractor began the examination with Murano & Mori Architects in the design stage, and the collaboration continued into the construction stage.

The second feature is that the contractors (the in-house design team of the general contractor, site work management staff, and specialist contractors) collaborated with the architects in the examination of embodiment and circumstantiation of design intentions, after the architects showed "what they would like to achieve." Architects examined from the architectural design perspective, and the in-house design team of the general contractor examined the functionality and constructability, which included the expenses and time required for completion. Following this, they decided on the design by communicating with each other. Particularly in the construction stage, the *Zumen-Kanri* persons examined and approved drawings and mockups prepared by the contractors.

The third feature is that the in-house design team of the general contractor played the role of adjusting and mediating communication between architects, site work management staff, and specialist contractors. The in-house design team of the general contractor conveyed design intentions of architects to the site work management staff and the specialist contractors. The team also communicated the demands of the site work management staff or specialist contractors regarding the construction execution to architects.

5. Conclusions

This paper presented two typical methods of collaboration between architects and contractors in Japan: the engineering collaboration method and the architectural collaboration method. Subsequently, as concrete examples of these methods, this paper examined former Japanese building construction projects led by Kunio Mayekawa and Togo Murano, and showed the methods of collaboration between architects and contractors in each project. Furthermore, the results of this paper revealed the features of collaboration between the architects and contractors, which are the interesting issues of comparison between Japanese and Western project delivery systems: what design team and construction team examine regarding engineering quality and architectural quality; who in the construction team participates in the design process; and who plays the role of adjusting and mediating between the design team and construction team.

In the U.S.A. and the U.K. two methods of collaboration between design and construction have become popular. One of them is the design-build process. The other is the bridging method used in the U.S.A. and/or the novation process used in the U.K. However, we have not fully grasped the actual features of these methods. For example, we are not sure whether people aim to collaborate between design and construction as Mayekawa and Murano or they try to restructure the traditional ways of risk sharing, such as the construction period and cost and, to separate stakeholders into schematic design and subsequent process. As forecasted in this time, they have come to collaborate aiming at better risk management in the U.S.A. and the U.K. On the other hand, formerly in Japan, the collaboration aimed to satisfy owners and confirm the quality of buildings after the general contractors had borne all risks. However, Japanese general contractors have been unable to bear such huge risks as was done previously. Therefore, collaboration with the explicit sharing of risks among people in building construction projects is henceforth necessary. For example, comparing the Japanese and Western change order systems and showing the differences between the two with regard to the sharing of roles and responsibilities may be useful in resolving the above issues. Thus, we will be able to conduct further study about them by examining real projects.

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A social network analysis of built environment national research centres in a national innovation program

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Abstract

This research seeks to describe the characteristics of the relationships within the clusters of academic-industry collaborative centres that contribute to built environment research through a longitudinal study. The creation and transfer of knowledge within such research collaborations is analysed over an eight-year period. The national institutional instrument of a program of Cooperative Research Centres supports collaboration between researchers, industries, communities and governments to solve major challenges facing Australia. The program purports to fund and seek participation from all sectors and disciplines. There is always conjecture from various disciplines that they are under-represented. In particular the built environment research community claims that although they have a large footprint on the GDP they are poorly resourced and supported financially through the CRC program and across all research funding programs in Australia. There has been no study specifically on the built environment cluster and there has been few broader empirical studies that explore past simple descriptive statistics. Various research questions were posed in the study with the aim of identifying strong and weak built environment research clusters over the eight-year period using social network analysis techniques. The research is seeking to explore the depth and scope of interdisciplinary research relationship capacity in the national innovation system. The analysis is in the early stages and preliminary results are presented in this paper. The CRC for Construction Innovation was explored in terms of level of interdisciplinarity and linkage strengths in the clusters. Interdisciplinarity and academic-industry and academic-academic linkage strength is a key structural characteristic of this particular built environment innovation cluster and this is not unexpected. However we challenge the traditional rhetoric, assumptions and beliefs on built interdisciplinarity and develop a much more informed discourse based upon empirical results and the theoretical discourse of academic-industry linkages with cross and trans disciplinary debates. The outcomes of this research can contribute to developing and managing future directions of research funding towards creating a more innovative built environment. This paper will be of interest to academics and various stakeholders in other countries seeking to lobby at a national level.

Keywords: academic-industry research collaborations, cooperative research centres, interdisciplinarity, social network analysis, built environment clusters

1. Introduction

A nation's health, growth and competitiveness is deeply influenced by its capacity to innovate. Over the last decade or so innovation in products, services and processes has become an increasingly important source of competitive advantage for individual firms and nations alike (Gerard et al, 2009). A nation's innovative capacity is defined by its ability to produce and commercialise a sustainable flow of innovations over the long-term and is reliant upon a number of factors. One of the key factors which can contribute towards improving a nation's innovative capacity is the level of inputs devoted to innovation in terms of research and development (R&D) manpower and spending (Furman et al, 2002). Within this context, industry-academic collaborations are increasingly being recognised as very valuable for innovations (Butcher and Jeffrey, 2005). A large number of technological advances and innovations have resulted from industry-academia collaborations (Hameri, 1996).

The national institutional instrument of a program of Cooperative Research Centres (CRC) supports collaboration between researchers, industries, communities and governments to solve major challenges facing Australia, many of which are global challenges (CRC, 2011). The CRC program is an initiative by the Australian government and is administered by the Department of Innovation, Industry, Science and Research (DIISR). The CRC program is an attempt to link researchers with industry to focus on R&D efforts towards utilisation and commercialisation whereby the close interaction between researchers and users of research is a distinctive feature of the program (CRC, 2011). The CRC program was initiated in 1991 to develop innovative solutions which are of high impact and applicability by end-users. The objective of the CRC program is (CRC, 2011): *"To deliver significant economic, environmental and social benefits to Australia by supporting end-user driven research partnerships between publicly funded researchers and end-users to address clearly articulated, major challenges that require medium to long term collaborative efforts."* The CRC program seeks to be inclusive by encouraging participation from all sectors and disciplines. CRCs typically have a number of participant organisations including universities or research institutions, businesses, governments at national, state and local levels, international partners, not-for-profit organisations and industry and community associations. A total of 190 CRCs have been funded since its inception which are organised into four sectors of Agriculture, forestry and fishing; mining; manufacturing and services. A commitment of more than $3.4 billion in CRC program funding has been made by the Australian government with CRC participants committing a further $10.9 billion in both cash and in-kind contributions (CRC, 2011). There is always conjecture from various disciplines that they are under-represented. In particular the built environment research community claims that although they have a large footprint on the GDP they are poorly resourced and supported financially through the CRC program and across all research funding programs in Australia. The other major program is the Australian Research Council. There has been no study specifically on the built environment cluster and there has been few empirical studies that explore other sectors. The CRC administrators conduct evaluative research as part of the government requirement to evaluate programs but these evaluations do not present anything much beyond simple descriptive statistics on value of programs. This paper does not address the question of the amount of funding provided to the built environment. We are concerned with aiming to understand the nature of interdisciplinarity in the research clusters. Whilst it is acknowledged that industry-academic collaborations promote innovations the complex and varied nature of such relationships need to be understood and explored

(Rappert et al, 1999; Butcher and Jeffrey, 2005). We are also interested in the nature of participation in these innovation clusters and the agendas that shape the institutional composition. Do certain academic and industry institutions have a predisposition towards interdisciplinary research and what is type of interdisciplinary research is undertaken? This is a pilot study to begin to develop theory and to test the methodology – the research will raise more questions than it answers. Therefore the paper seeks to begin to address the research question of: *What is the depth and scope of interdisciplinary research relationship capacity in the national innovation system of Cooperative Research Centres?*

2. Theoretical positioning

The discussion on the theory that underpins this paper is informed by literature associated with two key areas; industry-academic research linkages and interdisciplinarity. The literature on industry-academic research collaboration provides quite a few examples of interesting successful models and conceptual themes as well as the evolving understanding of built environment industrial –academic linkages.

2.1 Industry–academic research linkages

We identified in the literature on industry-academic linkages five key thematic areas including modalities and activities, institutional instruments, barriers and motivations. Each of these is briefly discussed to provide context to the research discussed in this paper. There are diverse modes of delivery of industry-academic linkages ranging from the formal to the informal (Rothwell, 1982; Mackenzie & Jones, 1985; Baba, 1988; NEDC, 1989). According to Martinez et al (1999) there have been many attempts to map and generalise such distinct approaches. But the working relationships leading to the transfer of knowledge are ultimately dependent on a diversity of communication and organisational networks uniquely shaped by each particular institution. One way of understanding the different modes is to consider the levels of engagement and the following three types are noted: first, academic consultancy type research whereby a firm seeks specific strategic advice or an applied investigative/experimental analysis on a project by project basis; second, collaborative research grants whereby experimental and applied problems are investigated and partnerships between academic and industry institutions are developed on a project-by-project basis and finally Strategic long term alliances and partnerships where there is a longer-term program of research and significant resource commitments by all organisations. These long-term arrangements in Australia can be found within the CRC program although there are other consortiums that have an extensive history and are found outside the CRC program and are more or less sustainable.

It is useful when considering these modalities to distinguish between ‘activities’, which are concrete means of effecting knowledge transfer, e.g. consultancy, contract and joint research and licensing and ‘institutional instruments’. Institutional instruments are the diverse structures developed by the organisations to implement a great variety of different activities (Martinez et al, 1999), for e.g research and innovation departments who manage negotiations and contracts government grants; research commercialisation arms of universities; university institutes, centres and groups; cross institutional centres; collaborative industry-academic Centres and Innovation Parks. Many of the past studies in this area have focussed on barriers to improving the partnerships. Various barriers have been identified and typically categorised as structural or institutional. Underlying structural barriers include fundamental different organisational and individual objectives between academia and industry namely; academic institutions exist to create and transfer new knowledge and industrial institutions exist to stay in business and grow the business. Therefore culturally and philosophically the strategic objectives fundamentally differ. According to Martinez et al (1994) “Each institution in the university-industry linkage is conceived as having a distinct, sometimes incompatible set of social, cultural and economic roles leading to serious differences in the code of values by which individual participants are ruled (Azaroff, 1982; Mattison, 1987; van Dierdonck et al,1990).” This of course creates a tension at the outset however these are not insurmountable. In practice there are barriers at the institutional level which includes operational matters such as negotiating lengthy administrative contract negotiations, poor project management, fragile egos; different timeframes (short business timeframes vs long term ‘science’ based research timeframes) and difficult intellectual property agreements. There are often challenges within the research project teams including personality clashes, lack of trust, poor communication, lack of respect for each other’s demands, different values and norms. Nothwithstanding such challenges there are distinct motivations for academic-industry linkages that have been well recognised by all parties. Motivations to be involved in academic-industrial linkages have typically been divided into the factors impacting upon academic institutions and the factors that impact firms in industry. Academic institutions have responded to the social and philosophical argument for academics to do useful research that helps industry and society (Rothwell, 1982; Van Dierdonck &Debackere, 1988). However the motivation is also driven by a more pragmatic need to address financial pressures and to respond to shrinking government budgets through diversification of funding sources. Interestingly as commented by Martinez et al (1994) nearly a decade ago evidence suggests that “periods marked by economic and/or technological turbulence in the US have provided appropriate conditions for university-industry linkages to flourish (Baba, 1988). Similarly, the economic crisis and the new trade policies have been fundamental driving forces for industry to seek cooperation with universities in Mexico (Waissbluth et al., 1988).” In Australia as evidenced by the CRC program industry-academic linkages has seen significant collaborations within parts of the mining, manufacturing and services sectors.

An exemplar of a sector-wide collaboration can be found in the biotechnology sector. The Australian biotechnology sector is small by international standards but is robust, growing and targeted by the government as a strategic priority. “Universities, research institutes, government agencies, non-profit organizations, leading hospitals, start-up firms and established companies have played key roles in either conducting and/or funding research. Increasingly complex research questions and widely dispersed expertise and resources have called for multi-disciplinary and multi-institutional approaches, as the needed skills and capabilities frequently are not housed in one organization. As a result, collaboration between teams and between institutions has become necessary, and a complex web of collaborations has proliferated in this field at multiple levels (multi-disciplinary, multi-institutional and multi sectorial) in recent decades. These events in the Australian biotechnology sector appear to mirror what is happening at the global level.” (Marot et al, 2005). The study by Marot el al (2005) provided a very fine grained analysis of the processes involved in the multi institutional, multi disciplinary and multi sectorial consortium including seven major research Universities and institutes and their associated affiliates. The findings are particularly focussed on the role intellectual property has as an organising element within the consortium. The way in which the consortium emerged and was evolving was described. The most important aspect of this study is the implications that this model of a consortium approach to stimulating collaborative capital (social, cultural, intellectual and resource capital) in complex innovation fields may enable creation of intellectual capital at the national level.

The CRC programs are fundamentally intended to achieve this outcome across various sectors and seek to bring collaborative efforts together under the one coherent umbrella research program. The collective capacities of the built environment cluster would be served by such an approach. This is not a particularly new idea as the inter-institutional agreements and approach to addressing the need to improve a nation's capability to exploit scientific and technological advances has been reasonably well considered (Smith, 1984; Mattison, 1987;). The trend shown in recent decades by several countries of reducing government expenditure on R&D (OECD, 1989) undoubtedly corresponds to a policy towards encouraging at least better use of resources in relation to research and development. Thus, the economic environment seems to be structural element significant to university-industry relationship development. At a more individual level academics in various disciplines may be motivated by more intellectual pursuits for eg the intellectual stimulations that enhance the quality of research at universities by suggesting new avenues for exploration (Smith, 1984; Cyr, 1985; Van Dierdonck & Debackere, 1988). In more vocational oriented disciplines such as architecture, engineering, construction management, nursing, medicine this may be coupled with the need to expose students to practical research and industrial practice related to their desire to improve scientific-pedagogical approaches within the curriculum in undergraduate and postgraduate programs. It is too often forgotten that academics in many built environment disciplines have had industrial experience – in some cases extensive experience at senior levels before they have entered academia full time. There are various pathways for the academic and although some in more scientific, engineering and medical disciplines are often traditional career academics many others have different academic trajectories. Built environment academics are often still very interested in responding to their original discipline challenges that they were exposed to whilst in practice. In many ways they are often motivated to explore the creation of exciting intersections between disciplines as they see that these interdisciplinary connexions may help to unlock some of the more significant industrial problems and expose new ways of exploring research problems. The advantages for collaborative research between industry and academia is not limited to academia. Firms are motivated to engage in industrial-academic linkages to improve research and development capacity through resource access and access to knowledge and innovations for competitive advantage (Martinez et al, 1994; Bloedeon and Stokes, 1994; Ingham and Mothe, 1998; Hagedoorn et al., 2000; Bozeman and Dietz, 2001). Firms can gain access to resources through infrastructure and new ideas, reduce costs and risks associated with new ventures and gain access to R&D funding (Moahn and Rao, 2005). In some cases senior managers of companies are simply motivated by altruism. In many cases sectors may be struggling to grapple with the challenges within their sector. Within the Australian construction industry in particular major failures on mega projects have characterised the sector in the last two years. Coupled with the project based problems there have also been significant challenges faced by the senior executive level of some of the larger corporations in terms of management of the entire organisation and its various portfolios and thus subsequent shuffling and reshuffling of people at strategic positions. More specifically in the housing sector the industry still addresses such problems as housing affordability, productivity and industrial competitiveness. It is anticipated that research and development can only contribute to addressing such challenges.

Much of the literature has tended to focus on collaborative processes, motivations, barriers and mechanisms whether at the institutional level, research group or individual. Interestingly there is a dearth of research about research productivity improvements made through collaborative efforts between industry and academia particularly related to the built environment. At times purists in research have misgivings about quality of research output and also that too little time may be devoted to the level of output and the real focus of the research as much time is taken up with administration, contract negotiations, politics and commercial activities. There is evidence to suggest that researchers' productivity does indeed increase with collaboration and that collaboration between researcher and industry has a significantly greater impact on productivity than collaboration between researchers (Landry et al, 1996). This has important implications for university executives and administrators and government policy decision-makers as it should encourage further collaborative initiatives. There appears to be little research on academic-industrial linkages that explores the role that interdisciplinarity plays across the field and inter-sectoral connexions – apart from the biotechnology example discussed previously. It is extremely difficult to conduct research across disciplines. There is very little real success in attracting funding for interdisciplinary research and yet the rhetoric is that it holds potential. The silo mentality not only exists in the academic institutions but also within the sectors. It is useful to explore some of the concepts that arise in the field of interdisciplinarity. There also appears to be little analysis or modelling to understand the actual structural nature of the linkages that support fields of research within these collaborative efforts to help to explain differences and similarities of performance between sectors and clusters of consortiums.

2.2 Interdisciplinarity context and discourse

There is often much rhetoric about the advantages of interdisciplinary research and yet the challenges are not often considered explicitly. Three topics are discussed briefly and related to this study to provide a context and consider some of the current discourse on interdisciplinary research including; defining interdisciplinarity, aims and problems. Disciplines are kinds of collectivities that include a large proportion of persons holding degrees with the same differentiating specialisation name, which are organised in part into degree-granting units that in part give degree-granting positions and powers to persons holding these degrees; persons holding degrees of this particular specialised kind are employed in positions that give degree-granting powers to them, such that there is an actual exchange of students between different degree-granting institutions offering degrees in what is understood to be the same specialisation (Turner, 2000, p47). This definition brings with it a number of associated themes including the ideas of professional bodies, markets, identity, boundaries and a body of knowledge. If we consider two very strong ideas of boundaries and body of knowledge it is here that we can provide some form of a simplified model of interdisicplinarity (London, 2005). A number of writers in this field have suggested that it is too difficult to define interdisciplinarity. However a useful conceptualisation is that provided by Maasen (p 174, 2000), "...interdisciplinarity presupposes (a) a realisation that certain topics cannot adequately be approached by a single discipline and (b) an identification of various disciplinary activities that converge on topics that - at first sight - might be capable of being conceptualised as a joint problem.

This type of interdisciplinary research can then be described as the act of transferring insights from different disciplines into a set of problems and a set of methods for approaching them. In the course of conceptually relating problems and methods, a certain something we call 'inter' may emerge with respect to the overall topic in question". "Disciplinary boundaries are rooted in academic undergraduate disciplines and interdisciplinary research is rooted in those undertaking research with a disciplinary background(s) transgressing other disciplinary boundaries when they approach a particular industrial, societal or research problem. Borrowing from other disciplines can contribute to an investigation of a research problem in two key ways; there is both content or knowledge contributions which disciplines can make as well as methodology and technique contributions " (London, 2005). Porter and Rossini (1984) noted that there is no satisfactory definition of what a discipline is and so suggested an idea of intellectual skills needed for problem-focussed research. They distinguished between two types of skills: substantive knowledge and technique. It is assumed that this is similar to theoretical concepts/principles and research methods/techniques. They developed a knowledge-technique skills chart whereby each point in the chart represents a knowledge-technique pair-a substantive knowledge area and a technique for processing knowledge of the area. An established research area comprises a fixed set of knowledge and technique skills, defined as a discipline. The discourse on interdisciplinary research can be understood through various metaphors that are used to describe disciplinary versus interdisciplinary research. Firstly, knowledge is often viewed in a territorial manner; we describe research areas or fields, which is partitioned into disciplines that are separated from one another by boundaries (Weingart, 1995; Klein and Thompson, 1996) and we see this in the Field of Research coding approach in Australia where this study is positioned. Interdisciplinary work is considered to be venturing to the 'borderlands' and to the 'frontiers' of knowledge. It is also considered through organic metaphors, growth areas and with images of knowledge diffusion. According to Wiengart (2000) the crucial feature of the discourse is the polarity of value. Disciplines carry images of being static, controlled, rigourous and conservative, therefore well grounded. Interdisciplinarity carries connotations of and is valued as being dynamic, flexible, liberal and innovative. However the positive valuations also are the source of negative views. For example, interdisciplinary research antagonists claim that it is research which is vague, lacks 'discipline' and rigour. Likewise, discipline research is considered too specialised and rigid and lacking in innovation - that the structure of disciplines is too simple to deal with representations of the real world in all its complexity. Of course there is merit in all arguments and interdisciplinary research can be both innovative and lacking in rigour and disciplinary research can be both rigid and innovative - this is considered to be the paradoxical discourse in interdisciplinary research (Wiengart, 2000). Perhaps what is more fruitful is to consider that the process of knowledge production (which takes place in disciplinary and interdisciplinary studies) is a process of specialisation and differentiation. Each interdisciplinary study can recombine knowledge from other fields, where it has been determined that something is lacking and needs innovation to explore the particular research problem. The challenge then is how do we categorise the research within the defined FOR codes?

2.2.1 Interdisciplinary patterns of study: borrowing, hybridisation and common ground

In considering how interdisciplinary studies are undertaken, Bechtel (1986) identified five patterns of disciplinary relations: developing conceptual links using a perspective in one discipline to modify a perspective in another discipline; recognising a new level of organisation with its own processes in order to solve unsolved problems in existing fields; using research techniques developed in one discipline to elaborate a theoretical model in another; modifying and extending a theoretical framework from one domain to apply in another; and developing a new theoretical framework that may reconceptualise research in separate domains as it attempts to integrate them. Clearly in an interdisciplinary study each discipline and/or sub-field can contribute to the research problem in a certain manner as indicated by Bechtel (1986). The contribution can take place in terms of theoretical/substantive knowledge and research methods/techniques and it can arise because one discipline/sub-field is deficient in relation to the research problem. Borrowing concepts from other disciplines or fields creates a hybrid character to the research. "Hybridisation is a biological metaphor connoting formation of new animals, plants or individuals or groups" (Klein, 2000 p9). This creates an intersection between fields and many such intersections occur involving techniques, specialised skills and instruments. However, intersections can also occur in interpretive acts, such as borrowing language and ideas. The borrowing of concepts and theories are generally much more influential than the simple borrowing of tools, data, results and methods (Klein, 2000). Although the claim is made that disciplinary research can represent specialisation and interdisciplinary research can represent generalisation through over simplification - neither discipline is well represented. The counter to this argument is that rigour and a depth of understanding can create an extremely specialised interdisciplinary study. The choice of disciplines becomes critical and it is the common ground and careful balance between each disciplines ontology, epistemology and methodology becomes critical. Typically many researchers working across boundaries are not seeking to change their ontology rather researchers seek to merge disciplines that align ontologies and create compatible methodologies. The interdisciplinary research requires a careful sifting and selection process to create a new common ground that converges disciplines and integrates partial spheres (London, 2005). The need for interdisciplinary research arises typically because a particular field is lacking or deficient but what is lacking is important to identify and too often this attention to analysis is superficial. A search into other disciplines creates a move across traditional disciplinary boundaries. The view of a discipline as a static well defined entity is problematic as disciplines can not be so simplistically defined, as they vary in the way they operate. A discipline/sub-field can be a "shifting and fragile homeostatic system" that evolves and adapts to changing environments (Heckhausen, 1972; Easton, 1991). One of the most challenging aspects of interdisciplinarity lies at the structural organisation of research disciplines and the ‘industry’ that has evolved in terms of funding research proposals. It is suspected that there is a genuine lack of expertise and subsequently support (both financially, philosophically and intellectually) for interdisciplinary research. The CRC programs which combine industry and academic groups appears to be a much more fertile ground for such interdisciplinary intersections. This raises an initial question which we have explored in this paper. *To what extent did the built environment innovation cluster have a predisposition and achieve interdisciplinarity and what is impacting upon interdisciplinary participation?* This question is positioned within the broader research question posed earlier which ultimately seeks to understand the capacity of the relationships between the industry-academic and academic-academic linkages to achieve better models of interdisciplinarity.

3. Research methodology

This is an ongoing research project which seeks to investigate the depth and scope of interdisciplinary research relationship capacity in the national innovation system of Cooperative Research Centres in Australia with a focus on the built environment research cluster. In order to achieve we begin to explore the following research objectives through the social network perspective: to explore and understand the built environment research clusters through social network analysis techniques and in particular the underlying structure of the clusters; to identify the strength or density of built environment research clusters and to identify the extent of interdisciplinarity between participants in built environment research clusters.

Social network analysis (SNA) is a body of collective methods developed to analyse social networks (Davies, 2009). SNA has its origins in sociology and mathematics but has since received an explosion of interest particularly in the past decade by researchers in a range of areas including health, business and electronic communications (Borgatti and Li, 2009). Unlike some concepts related to the study of social relationships (for eg. guanxi) SNA is not linked to a specific social theory, however, is an orientation towards the social world that gravitates itself to a particular set of methods (Scott, 2010). It should thus be seen as a form of research tool which seeks to describe social structures in terms of networks of actors and to interpret actor behaviour based upon their positions within the social structure (Marsden, 1990). SNA's main point of difference from other types of analysis of social phenomena is its focus on the *structure* of relationships between actors instead of the *attributes* of actors (Davies, 2009). It is a relatively new mode of analysis given that up until the mid-twentieth century the typical way of explaining social phenomena was based primarily on the attributes of actors (Borgatti and Li, 2009). The shift to a more relational perspective undertaken by SNA researchers considers both the social environment within which the actor is embedded as well as the characteristics of the actor. Therefore SNA is particularly relevant for understanding the structural characteristics of the linkages within the national innovation system of CRCs. The CRC for Construction Innovation's website was used as the main source of data. The website contains comprehensive information about the CRC including its activities, programs of research, funded projects and publications. The website lists the titles of all the research projects which have been funded by the CRC CI since 2001 in the various programs as well as participant organisations involved with each project. We retrieved information relating to each participant's institutional affiliation according to type of institution (academic, non-academic research, industry, government, industry organisation) through individual websites of the organisations. We also collected disciplinary data relating to the academic organisations in terms of fields of research (FOR). The FOR coding system is an indicator of the discipline that researchers lie within. The Australian and New Zealand Standard Research Classification scheme (ANZSRC) (ARC, 2012) was used to facilitate the coding of the academic organisations' disciplinary affiliations. The ANZSRC classifies fields of research into 2-Digit, 4-Digit and 6-Digit Codes. The 2-Digit Codes categorise major fields (for eg. Built Environment and Design) whilst the 4-Digit codes relate to sub-fields (for eg. architecture, building, etc). The 6-Digit codes go into more specialised fields (for eg. architectural design, building construction management and project planning, etc). The 4-Digit codes perhaps align more closely to what we tend to relate to as traditional disciplines and the 2-Digit codes group together disciplines clustered around the following categories: sciences; engineering; technolog; medical and health sciences; built environment; education; economics; commerce management tourism and services; studies in human society; psychology and cognitive sciences; law and legal studies; studies in creative arts and writing; language, communication and culture; history and archaeology' philosophy and religious studies. For the purposes of this study we categorised the academic organisations into 4-Digit codes to enable a clearer understanding of the specific disciplinary affiliations of the organisations and hence the level of interdisciplinarity of clusters. The preliminary results reported in this paper show the level of interdisciplinarity based upon the project leader FOR codes and is reported at the organisational level rather than the FOR codes of the key researchers at the project level. The next stage of analysis will involve a more detailed classification of 4-Digit codes based on the individual academics within organisations working on specific projects. Ultimately the outcomes of the project are coded by researcher however this type of data may not be as easy to track and access. All the data was entered into an Excel Spreadsheet database prior to being exported into UCINET. UCINET is a widely used social network package for storing data in simple matrix form and was adopted for use in this research based on its capacity to produce a range of measures which are most meaningful and appropriate to the problem being investigated. UCINET utilises NETDRAW, which is a network visualisation package to graphically visualise social network data. Two major reports produced by the DIISR were also used to provide general background information relating to all the CRCs which have been funded to date. The reports are: CRC Directory: Cooperative Research Centres Program 2011-2012 (DIISR, 2011) and Cooperative Research Centres Program: CRCs over time (CRC, 2011).

4. Results

The CRC for Construction Innovation (CRC CI) was established in 2001 and headquartered at Queensland University of Technology (QUT). It was a national research, development and implementation centre focused on the needs of the property, design, construction and facility management sectors. The CRC CI represents the most significant commitment ever made to construction research in Australia involving a seven year $14M commonwealth grant and $53M in industry, research and other government funding (CRC CI, 2012). The CRC CI had more than 350 individuals and 29 leading partner organisations participating in its activities. Research projects funded by the CRC CI were organised into three programs including Business and Industry Development, Sustainable Built Assets and Delivery and Management of Assets. In 2007 a two-year extension program was undertaken to continue the implementation of the outcomes achieved through its projects with a focus to improve productivity and sustainability of the industry. A total of 67 projects have been funded as shown in Table 1. Each project typically involved at least one academic and/or non-academic research institutions and a number of other partner organisations from industry and/or government. The majority of projects involved 5-6 organisations. Many of the organisations tended to be involved in more than one project, with one organisation in particular (CSIRO) being involved in up to 21 different projects. The type of organisations include developers (4), construction contracting organisations(4); architects (1); urban design/architecture(1); government public works (6); universities/research institution (6); government regulators (4); engineering (1); quantity surveying/project managers (1); client (1).

Table 1: Number of research projects funded in the four CRC CI programs

	Business & Industry Development	*Sustainable Built Assets*	*Delivery & Management of Assets*	*Extension*
Number of research projects	*19*	*22*	*21*	*5*

4.1 Network analysis and measures

The network analysis on this study involved mapping the relationships between participant organisations of CRC CI projects. Figure 1 is a network mapping of all the participant organisations involved with CRC CI projects. Each "node" represents an organisation which participated in the research projects. There are a total of 29 nodes in the network, each node with an individual set of attributes. The attributes include the institutional affiliation and number of disciplinary affiliations, which are represented by the colours, and shapes of the nodes respectively (refer to Legend in Figure 1). Network mapping diagrams of each of the four programs are included in the appendices section of this paper (refer to Figures 4, 5 and 6 in appendix). The size of the node indicates that it had more projects and links with other organisations. Queensland University of Technology, Qld Department of Public Works were the organisations who had the most projects and linkages. Then there was a small group of organisations who then fell in the next tier of significant players in this CRC which included University of Newcastle, John Hollands Group and Qld Department of Main Roads. It is noted that this only recognises number of projects and number of linkages between organisations it does not consider volume of funding for projects. Within these two tiers the key research organisations of QUT and UoN there FOR code grouping was 7 and 4 respectively. RMIT had 5 FOR codes and fell within the next tier of number of projects and linkages. University of Sydney and University of Western Sydney had 1 FOR code and Curtin University had 3 FOR Codes. At this stage the academic institutions were only examined for interdisciplinarity through the number of FOR codes that they exhibited.

Relationships between nodes are technically referred to as "ties" whereby the strength of a tie between two organisations is measured by the number of projects which both organisations participated in. Therefore the more projects that two organisations have worked together on, the stronger the tie between them. The network data was filtered by the strength of relationships between nodes to compare a map of all relationships against the more important ones. Through the filtering method in NETDRAW the weakest ties in the network were "filtered out" leaving only the stronger ties visible in the network map as shown in Figure 2 (refer to appendix). A further level of filtering through an increase in the number of ties resulted in the network map in Figure 3 (refer to appendix). There appears to be strong ties between the universities who are exhibiting greater levels of interdisciplinarity; ie QUT and UoN and then QUT and RMIT.; with the strongest tie between the research organisations that have the highest level of interdisciplinarity as indicated by number of FOR codes.

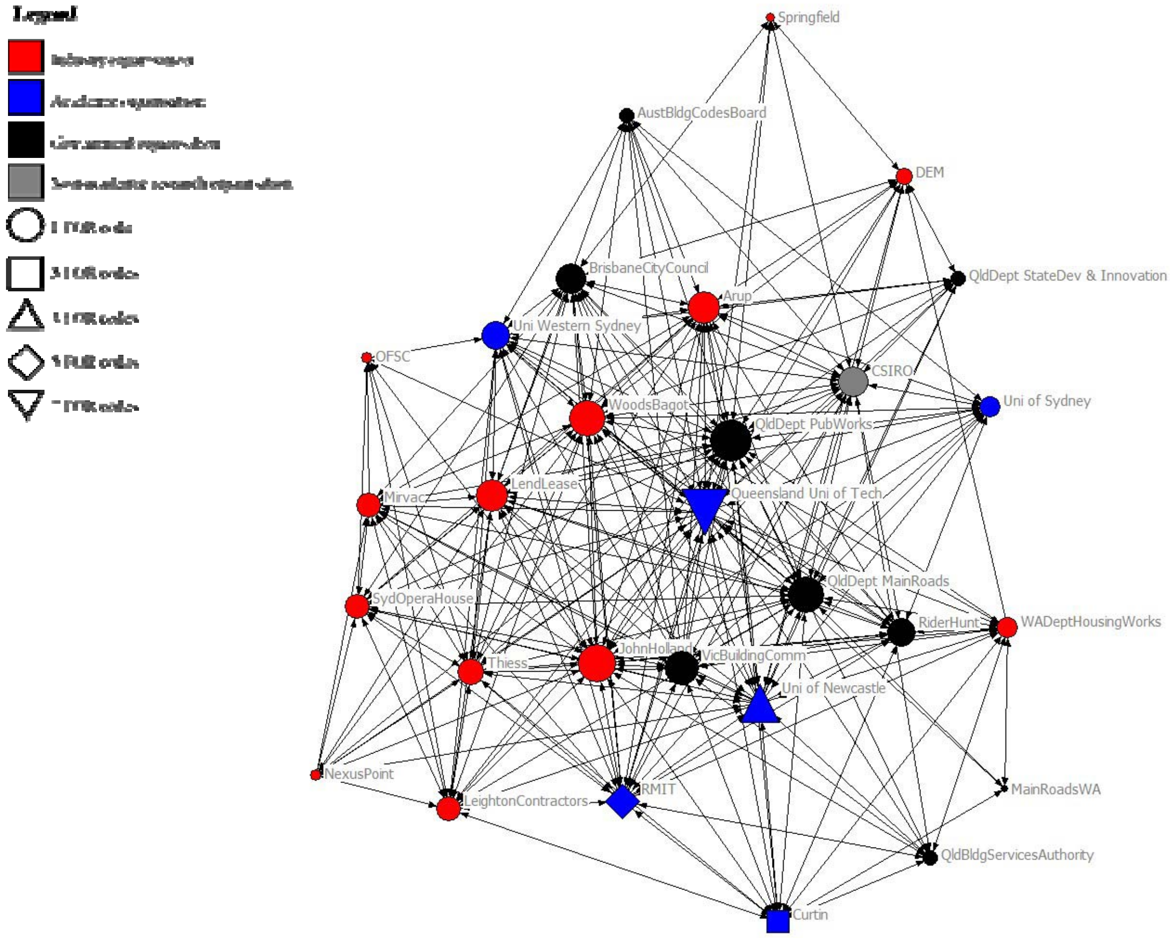

Figure 1: Network ma

participant organisations in CRC CI projects

Centrality is a central measurement in the analysis of social network data and is concerned with the relative centrality of various points (nodes) in a graph (network) (Scott, 2010, p. 82). Arrows between nodes are referred to as "indegrees" and "outdegrees". An indegree is the number of ties going into a node and an outdegree is the number of ties leading out from that node and into another. An analysis was conducted to count the number of indegrees and outdegrees of each node to reveal those organisations which are most important in the network. The centrality of organisations in the CRC CI network is represented by the sizes of nodes, ie the larger the node, the more central the organisation. The most central node is Queensland University of Technology (QUT) which is also the academic organisation with the most number of assigned FOR codes (7). Other central nodes include Queensland Department of Public Works (QDPW), Queensland Department of Main Roads (QDMR), University of Newcastle, Woods Bagot, John Holland, CSIRO, Arup and Victoria Building Commission. C**liques** is another useful concept for measuring the importance of certain organisations A clique is a subgroup of actors who are directly connected to one another and clique analysis is commonly used in the identification of dense subgroups within a network (Hawe et al, 2004).

Participants within cliques communicate with each other more frequently than they do with others. Furthermore there is often more than one clique identifiable within a network and there tends to be substantial overlap among actors identified in cliques (Hawe et al, 2004). An analysis of the overlapping enables the identification of the core members within the network, who are considered to be particularly powerful. An actor who is a member of multiple cliques is called a bridge and is a good indicator of their social power. A clique analysis performed on the CRC CI network identified 13 cliques (refer to Table 2.). Table 3 FOR across University organisations provides some context to the nature of the disciplines involved in RMIT, QUT and UoN. QUT was the most diverse drawing from civil engineering, building, physical chemistry, materials engineering, information systems and law. RMIT drew from building, engineering design, civil engineering, mechanical engineering and business/management whilst UoN drew from architecture, building, design practice and management and civil engineering. We most note that since QUT was the headquarters of the consortium and was funded the most this may introduce some bias to the results. The number of projects funded could correspondingly increase the FOR codes and could also bear on their social power in the network. In the next phase of analysis when we explore the number, type and funding volume of projects we shall examine the proportion of FOR codes to number of projects and compare the results obtained. . There were also different programs of research within this CRC (refer to Appendice Fig 4, 5 and 6). We have yet to analyse the relationship between type of project and interdisciplinarity. The individual researchers within the institutions is a much more complex and difficult stage of data collection however this will help us to explore if different types of research projects produce different levels of interdisciplinarity. We also have not matched levels of funding and if this has any impact upon interdisciplinarity. The levels of participation in interdisciplinary research also is impacted upon the type of industry and government organisations that are involved and the shaping of research problems as well as the type of researchers. Even though researchers may be aligned with one FOR code does not necessarily mean that the project was not interdisciplinary; for example, the contribution of knowledge may occur in the FOR Building code 1202 but it may have had input from other researchers who code their outputs differently.

Table 2: Cliques identified in the CRC CI network

	Participants in cliques
1	*Arup RMIT BLendLease JohnHolland QDMR QDPW QUT UoNewcastle VBuildingCommission*
2	*Arup RMIT CSIRO JohnHolland QDMR QDPW QUT UoNewcastle*
3	*RMIT BrisbaneCityCouncil CSIRO JohnHolland QDMR QDPW QUT UoNewcastle*
4	*RMIT BrisbaneCityCouncil JohnHolland QDMR QDPW QUT RiderHunt UoNewcastle*
5	*RMIT JohnHolland QDMR QDPW QUT RiderHunt UoNewcastle VicBuildingCommission*
6	*Arup CSIRO JohnHolland QDMR QDPW QldUTech UWesternSyd*
7	*Arup BLendLease JohnHolland QDMR QDPW QldUTech UWesternSyd*
8	*CurtinUTech QDMR QDPW QldUTech RiderHunt WADeptHousingWorks*
9	*Arup CSIRO QDMR QDPW QDSDTI QldUTech UWesternSyd*
10	*Arup CSIRO QDMR QDPW QDSDTI QldUniOfTech UniOfNewcastle*

11	*CurtinUniOfTech MainRoadsWA QldDeptMainRoads QldUniOfTech WADeptHousingWorks*
12	*Arup CSIRO QldDeptMainRoads QldDeptStateDev&Innovation QldUniOfTech UniOfNewcastle WoodsBagot*
13	*Arup DEM QldDeptStateDev&Innovation QldUniOfTech UniOfNewcastle*

Of the 13 cliques QUT were involved in 12; University of Newcastle were involved in 8 cliques; RMIT were involved in 4 cliques, Curtin were involved in 2 cliques, University of Western Sydney were involved in 3 cliques and University of Sydney was not involved in any cliques. Clearly QUT has the greatest social power in this network and as they have the greatest number of FOR codes and the influence of interdisciplinarity has the potential of being more effective. Coupled with University of Newcastle's social power which had 4 FOR codes the effect of interdisciplinarity as a mode of research practice appears influential in this cluster. When we then consider the strong ties between QUT and RMIT and QUT and UoN (and remembering that RMIT had 5 FOR codes) we are beginning to see a relationship between interdisciplinarity and the modality of the academic-academic linkages in this cluster. Interdisciplinarity in this CRC appears to be an important factor in terms of significant nodes and tie strength. Our next phase is to explore whether or not this sector and this particular CRC is any different to other CRCs.

5. Concluding remarks and further research

The basis of an innovative country lies in its capacity to successfully create and transfer new and commercially useful knowledge amongst various actors in its innovation systems. Industry-academic collaborations are increasingly being recognised as very valuable for innovations, however, the complex and varied nature of such relationships have yet to be understood and explored in depth. As previously indicated this research is an ongoing study which seeks to address the research question of: *What is the depth and scope of interdisciplinary research relationship capacity in the national innovation system of Cooperative Research Centres?* The underlying premise is that the built environment is an extremely large and diverse innovation cluster and long and fragmented industrial supply chains with numerous stakeholders. It is anticipated that those stakeholders are from quite diverse disciplinary backgrounds and as yet we have not unlocked the potential capacity for extensive and deep research collaborations across multiple organisations and multiple discipline backgrounds. Significantly this innovation cluster did not have any manufacturing or specialist subcontractors as industrial partners and this would seriously impact the nature of interdisciplinary research –also few specialist consulting design firms were really very well connected to the research projects. There was little participation in social sciences, humanities and information sciences and yet many of the outcomes were within these discipline domains. In some parts of the built environment cluster the tradition of academic research is not as widely acknowledged or regarded as other more scientific based disciplines and the issue is often that built environment researchers focus on more broad problems and can not divorce themselves from thinking about the whole (systems and systemic thinking) rather than about the minutae. Because of this, there is some reluctance to engage, trust, commit, value and collaborate with the academic institutions over many years the recent reforms to the R&D incentives in Australia may still pose a challenge to our industries. There is a tendency to not fully understand the nature of interdisciplinary research; for example a project may be cast as a ‘law’ problem and so we seek leadership from a law researcher rather than input from legal researchers whether they are outside the built environment disciplines or within the built environment disciplines. More sophisticated models of interdisciplinarity need to be developed so that we are clear about the past research on topics and the positioning of the work to each field of research if in fact the work does contribute to both fields of research. We also find that there is a low knowledge base in our senior managers in how to capitalise on R&D incentives. The new reforms fundamentally ask for specific contributions of research to the knowledge base of the discipline and not simply that an industry organisation is ‘going out and finding out something’ – which in fact would be new to the organisation (or to the very small unit or department within that organisation) but in reality are not a contribution to the knowledge based within Australia let alone universally to the body of knowledge internationally. There is so little cohesion in the Australian built environment research disciplines and so little cohesion and real understanding of the type and nature of research being undertaken in the research institutions – the fragmentation fundamentally challenges the capacity to make progress. In comparison to much more innovative sectors we have a long journey to take to build capacity in understanding conceptually, collaborative capital in such research networks. We contend that we don’t understand enough about the underlying structural and behavioural characteristics of the built environment innovation cluster in relation to the industrial-academic and academic-academic, and industrial-industrial linkages in relation to interdisciplinary research and that there is something fundamentally different between our cluster and others. We also contend that this difference may be addressed through exploring better ways to address interdisciplinarity and promoting a model of collaborative capital. This paper has provided a snapshot view of the overall network of CRC CI built environment cluster. The paper has begun to highlight some key characteristics of the relationships within the clusters of academic-industry and academic-academic collaborations that contribute to built environment research. The next stage of the study involves a deeper analysis of the network measures in this cluster and then cross comparisons to other clusters that are considered to be high performing. It is anticipated that this understanding will contribute to developing and managing future directions of research funding towards creating a more innovative built environment. The outcomes of this research will be of interest to academics and various stakeholders in other countries seeking to lobby at a national level.

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7. Appendix

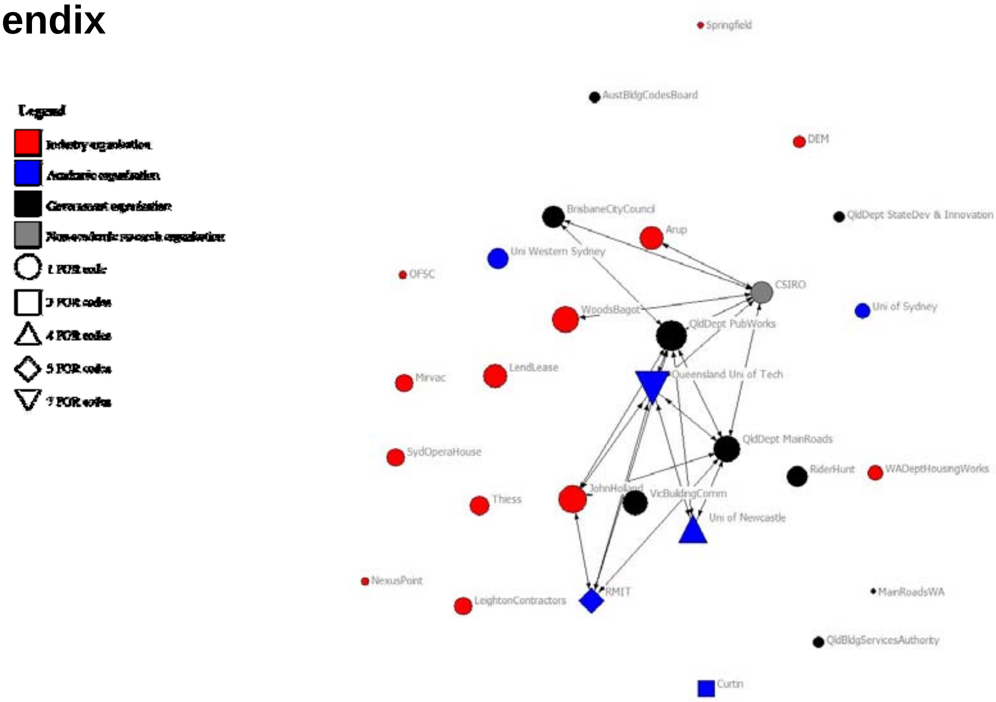
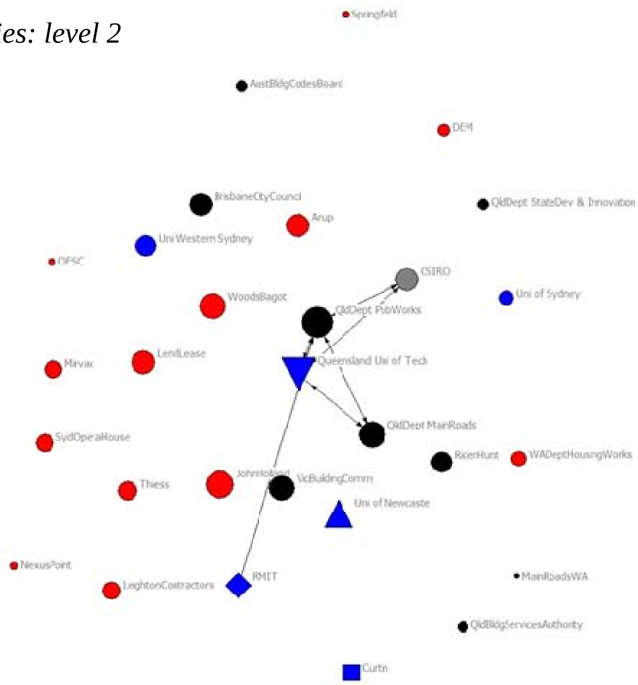


Figure 2: Filtering of weaker ties to reveal strong ties: level 1

Fig 3: Filter of weaker ties to reveal strong ties: level 2



ID	2 Digit	4 Digit	2 Digit	4 Digit FOR code	Sector
RMIT_DSC	3	5	12, 09, 15	1202, 1204, 0905, 0913, 1503	Mfg
QUT_SE	6	7	12,09 08,15,03,18	1202, 0905/12,0806, 1503,0306, 1801	Mfg
UoN_EBE	2	4	12	1201, 1202,1203, 0905	Mfg
UoS_ADP	1	1	12	1203	Mfg

Table 3 Fields of Research Codes across University participants

Evaluating Construction Project Complexity

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Abstract

Complexity is a key characteristic of construction projects. It is the degree of complexity that determines the overall approach to a project, specifically the required resources as well as tools and techniques. While we have means to quantify the complexity of e.g. a mathematical algorithm, no ways have been proposed today to quantify the complexity of construction projects. To this end we propose to conceptualize complexity with five dimensions (task, social, cultural, operative and cognitive complexity) and a number of factors determining each of these dimensions. The evaluation process is carried out by a group of experts that determines a value for each factor and accordingly for each one of the five complexity dimensions. In addition, the experts determine a weight for each dimension. The data allow calculating a complexity index of the project. The index is then compared to thresholds of a predefined classification system that represents the experience of the company for which the group of experts is doing the evaluation.

The result is a robust index expressing the inter-subjectively shared opinion of the group of experts. The process breaks down the construct "complexity" into a large number of factors. The quantification of each single factor might be somewhat of target. Some will be overestimated with regard to complexity; others will be underestimated. However, if no bias prevails, the index as the weighted sum of the factors represents a fair evaluation according to the law of large numbers. The complexity index cannot be compared when different groups of experts evaluate projects since the evaluation process is based on the groups' ability to deal with complexity. Experienced companies will find the same project less complex than inexperienced ones. Since the complexity index shall be used to determine what resources, tools and techniques are appropriate for a specific project, this subjectivity is not a drawback but welcome: it allows each company to tailor an approach that is in harmony with their past project experience.

This paper shall provide a discussion of chances to develop and apply the kind of complexity assessment application presented above. A first stage solution is under development and the early results from that together with previous research form the basis of the paper.

Keywords: Construction projects, complexity index, expert evaluation, construct, benchmarking

1. Introduction

Complexity is an intriguing characteristic of construction projects. In almost every text on project management or its adjacent fields of studies such as estimating, scheduling, logistics, or supply chain management, the complexity of construction projects is mentioned (e.g. Bennett 1991, Mubarak 2010, Sullivan et al. 2010). It has become a term such as “large” and “beautiful” where evaluation and understanding lie in the eyes of the beholder. Scores of articles have been written on complexity, alas there is no agreement!

Sargut and McGrath (2011) define a simple system by a low degree of interaction and dependable predictability; complicated systems comprise many elements and many interactions functioning according to clear patterns, they are also predictable; complex systems are identified by the terms of multiplicity, interdependence and diversity, their outcomes are difficult to foresee. The same system configuration at the start allows for different results. Gidado (1996) is taking a different approach by concentrating on components (inherent complexity, uncertainty factors, number of technologies, rigidity of sequence, overlap of stages) and interactions between these. For him, complexity purely has a technical character. These positions are representing two ends of a continuum for the definition of complexity: the first one is highly abstract and flexible, the latter one concrete and more rigid. Seeing complexity not only from a technical perspective is a rather new topic (Antoniadis et al. 2012). An abstract definition allows to incorporate nontechnical perspectives and for this reason we will approach the definition of complexity from this end of the continuum.

It seems to be difficult to define complexity without a framework. A suitable one is Luhmannian system theory which understands the world as unmanageable due to its overwhelming complexity. Therefore, we are required to create systems in order to reduce complexity to a manageable degree. Construction projects are one type of system. Depending on how we draw the system borders of a construction project (one family home or petro-chemical plant) we are facing a remaining complexity, an eigen-complexity (Luhmann 1995). Drawing on the definition of Sargut / McGrath, we would like to add another dimension to the discussion, i.e. impact. It does matter whether a cause at one point of a system has a large or a small effect to the configuration of the system (Wilke 2000). The interactions between the elements are loaded or weighed (Geraldi 2008). This is, of course dependent on the diversity of the elements. Diverse elements allow for different types of impacts rippling through a system. Strength of impact is a more direct characteristic and therefore better suited for a definition than diversity.

A word of caution needs to be added. We are only concerned about complexity when we have to consider it for decision-making. An esoteric view of complexity is never taken in this paper. The whole point of systems theory is creating manageable entities that enable us to make decisions. This has consequences since the work of Simon (1972); we deal with bounded rationality and incomplete information. The first one is seen as a human condition, the second one as a result of the system’s remaining eigen-complexity. Construction and construction projects appear to be systems where their complexity is linked to uncertainty of different actors and factors forming the actual system. It is likely that complexity management can be improved if the nature of complexity is identified and unnecessary complexity decreased (Pennanen & Koskela 2005).

2. Methodology

Evaluating project complexity involves several steps: (a) describing projects as a framework; (b) defining complexity; (c) deducing the construct “complexity”; (d) developing a method to measure complexity; (e) determining the value of project complexity. Through steps (a) to (c) project complexity is conceptualized; this is elaborated in chapter 3. Steps (d) and (e) are operationalizing project complexity and are treated in chapter 4.

The methodology used is logical deduction. Projects are embedded in Luhmannian systems theory (Luhmann 1995) and as such they form a distinct system through differentiation from the environment. The New Institutional Economics (NIE – Williamson 1985) are used to describe construction projects from a contractual point of view as contract goods. A nominal definition of project complexity is given based on a literature review (e.g. Baccarini 1996), combining this with a systems and NIE perspective. The construct is deduced from literature again embedded in Luhmannian systems theory (Wilke 2000). The construct is multi-dimensional and multi-factorial. As such it can be tested by a variance analysis; however, this is not described in this paper.

Steps (d) an (e) are of a more practical nature. The quantification of project complexity is determined by a group of experts to achieve an intersubjective agreement. We do not propose an objective measuring theory. This is due to the nature of complexity: this is a construct, nothing that exists in nature in a way similar to gravity. Thinking of complexity as a physical phenomenon has no ontological foundation whatsoever. With regard to a comparison between physical and social science and especially with the possibility of translating social theories into predictions of specific events such as it is possible with natural laws Hayek (1967) observes: “*There is no justification for the dogmatic belief that such a translation must be possible if a science of these subjects [social subjects]is to be achieved, and that workers in these sciences have merely not yet succeeded in what physics has done, namely to discover simple relations between a few observables. If the theories which we have yet achieved tell us anything, it is that no such simple regularities are to be expected.*”

3. Conceptualizing project complexity

3.1 Prologue: construction projects as contract goods

Projects are at the core of the construction industry and are typically defined by a contract, uniqueness of the task, a specific organization, an estimated budget and a given construction period. A little less common is the definition of construction projects as contract goods. Contract goods are defined by a contract (with a scope, parties to the contract, a budget and a timeframe) and they cannot be handed over when signing the contract. It takes the construction period to deliver them. The opposite is found in exchange goods such as a car which the buyer can view and test drive before concluding a contract. During the construction period the immaterial contents of the contract are transformed into the material structure by cooperation between client, consultants, contractors and suppliers. Contract goods are embedded in the principal/agent-theory and thus allow for a thorough analysis (Holmstrom/Milgrom 1991, Sappington 1992, Varian 1992, Nicholson /Snyder). Immateriality and integrativity characterize contract goods and there occurs a change in essence over the production period. If we think of contract goods to be delivered in three phases (before signing the contract – ex ante, during production, after finishing – ex post), then we can distinguish between two alternatives for contract goods: goods that remain from beginning to end immaterial such as hair cuts or those that are being transformed into something material such as construction projects (fig. 1).

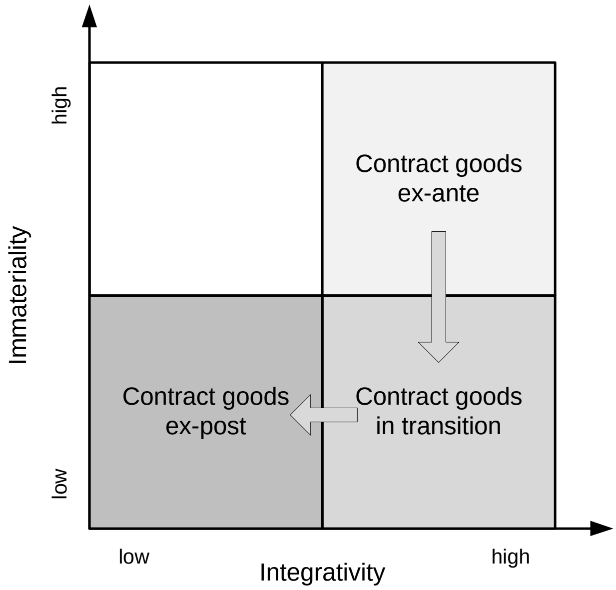

Figure 1: Construction projects as contract goods

As the nature of construction projects change when understood as contract goods, it is also clear that its complexity changes. Therefore we have to decide for what state we want to evaluate the project complexity. It seems natural to choose the moment of signing of the contract, thus we propose to take an ex-ante perspective. In this case we are confronted with the full complexity of the project execution (this might include design) but we do not worry about the complexity of the tendering phase. Such an ex-ante complexity allows the client to assess the capabilities of a bidder against demands and the contractors to submit a correct offer.

3.2 Definition

Following the discussion in chapter 1, we like to put forward a nominal (or stipulative) definition of complexity comprising number of elements, number of interactions and the strength of the impact that ripples through these interactions to the elements. Such a definition does not aim to reveal the essence of complexity and thus it cannot be right or wrong; however, it can be practical or impractical. The further discussion will reveal its practical usefulness. This definition is abstract in line with Sargut/ McGrath (2011) and a number of other authors. It seems that the efforts of finding a definition converge on such three characteristics with two of them (elements and interactions) being fixed and the third one under scrutiny.

Complexity = (def.) the number of elements, their interactions and the strength of impacts of a defined system with regard to decision making

It should be noted that this definition is a general one referring to any type of system. For a construct of construction project complexity we will find further determining factors. Complexity does not remain constant over the life-span of the project (compare chapter 3.1). In the end, the aim is to reduce it by decision-making. Therefore we are faced with different configurations of complexity at different times. Construction project complexity is subjected to dynamic change. As complexity here is seen as a state of a configuration, dynamics cannot be part of the concept of complexity itself. However, a dynamic environment produces different configurations and levels of complexity (Girmscheid and Brockmann 2008).

3.3 Construct dimensions of complexity

As mentioned, the discussion on complexity has progressed from just considering the technical complexity to include other categories. Baccarini (1996) for example distinguishes between organizational and technological complexity. Girmscheid and Brockmann (2008) introduce task, social and cultural complexity based on Wilke (2000). Task complexity combines technological and parts of organizational complexity, especially planning and organizing. It excludes leadership which is part of the social complexity. There can be little discussion that the number and diversity of stakeholders in a project along with the strength of their impact (interest and power – Chinyio and Olomolaiye 2010) increases its complexity; this we term “social complexity”. The same holds true for the influence of culture on construction projects (Tijhuis and Fellows 2012, Kähkönen 2008). In all cultural studies the point is to show how much the stakeholders’ cultural diversity influences project outcome. The more cultures meet in a project, the more complex it becomes since it requires coordination of an increasing number of different cognitive maps (Brockmann 2009); this we term “cultural complexity”. Geraldi (2008) also refers to dynamism with regard to complexity. We subsume something like dynamic complexity under the term “task complexity”. A stable environment certainly facilitates all tasks.

Two additional forms of complexity can also capture dynamics: cognitive and operative complexity. They both develop over time. Cognitive complexity mirrors how differentiated we think about a construction project; this increases with time as we understand a project better. Operative complexity is the degree of freedom for members of a project with regard to its operations and the project sponsors. Are most operations determined by the sponsors or does the project develop its own more specific operational approaches and thus become more complex?

A confined space influences task and social complexity. Restricted space for the tasks (i.e. a limited construction site) and social interactions (i.e. limited office space) increase these two types of complexity. All five types are becoming more complex as less time is available. This is a result of the decision-making perspective. The discussion can be summarized in a graph (fig. 2).

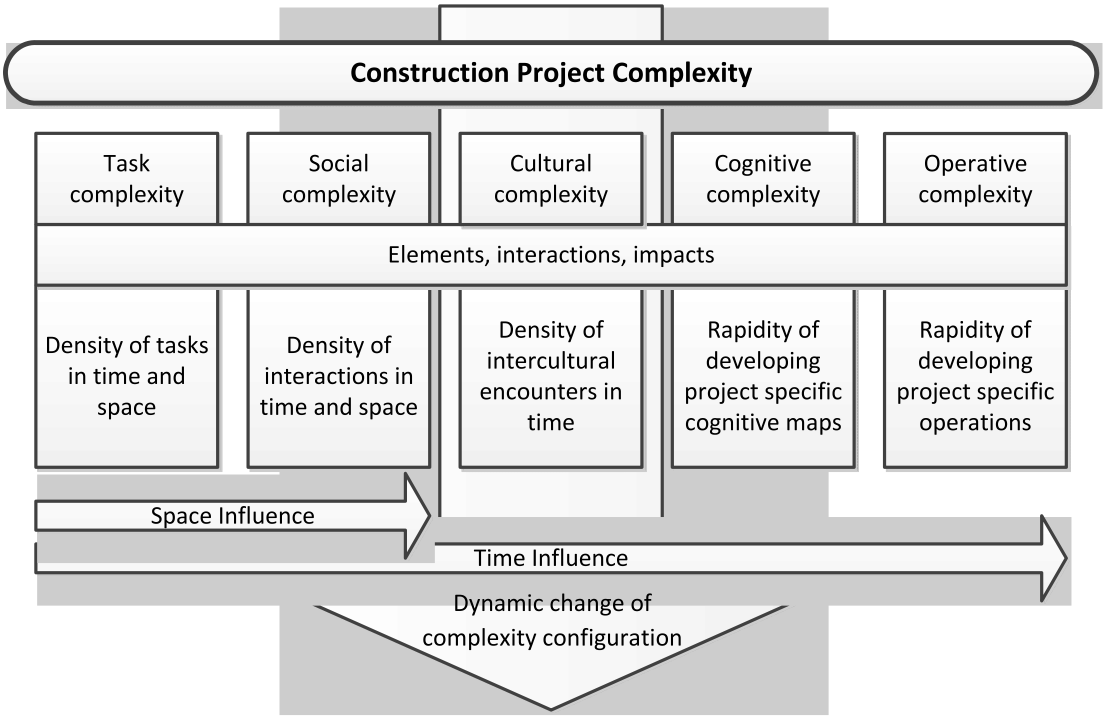

Figure 2 : Concept of construction project complexity

Returning to the discussion of construction projects as contract goods, it becomes clear that with the fulfilment of the contract all five complexity dimensions are reduced to zero. The task is completed, the project organization dissolves, cognitive maps are used for other purposes and operations cease. While this is true for the project it is not true for the institutions involved, their people might meet again in another project and bring along a – large or small - bag filled with history.

3.4 Factors of the construct dimensions

Up to now we have elaborated five construct dimensions. These are again determined by different numbers of factors and these we will discuss in this chapter. Number of elements, interactions and impacts are factors of all five dimensions as they are part of the general definition.

Task complexity: The concept of “density” has two categories. The first one applies to decision making and here time pressure increases complexity. There is not enough time to gather information and to analyze the situation. Space limitations also increase complexity. We only have to think of large numbers of subcontractors working in a confined space. It takes good planning to avoid an avalanche of claims and good luck to finish with just a few.

Social complexity: Similar to task complexity, social complexity rises when interactions take place in a short period. Time pressure comes across as chaos because there simply is not enough for coordination. Space limitations are not a real problem, the opposite is true: the scattered locations (dispersion) of a project team increase complexity (Dainty et al. 2006). This is definitely a challenge for international projects.

Cultural complexity: Culture becomes only problematic when different cultures meet. A good help for measuring the differences between cultures is the work of Hofstede/Hofstede (2005). They provide data for many different cultures and use five factors for describing culture: power distance, uncertainty avoidance, masculinity, individualism and long-term orientation.

Cognitive complexity: All the people in a project come with somewhat different mindsets, i.e. different cognitive maps. This is captured in the dimensions social and cultural complexity. Cognitive maps provide us with orientation without the necessity to analyze the situation from the beginning. The important point is that the people in a project dispose of appropriate maps. When a project is unique, we have to adapt our maps to the situation at hand, this is a learning process. However, the maps we start the process with should be as applicable as possible. A little simpler said: we need to have the required know that. Cognitive maps have also been called frames. Snow / Benford (1988) and Gamson (1992) define three types of sub-frames: (1) diagnostic frames, (2) identity frames, and (3) prognostic frames. These can serve as factors for cognitive complexity. The question for evaluating project complexity is here to determine ex-ante whether the people that will be decision makers for the project have access to applicable cognitive maps or not and whether they are capable to develop these maps in accordance with the project. Should this not be the case, then this fact will increase the project complexity. Diagnostic frames help analyzing situations appropriately, identity frames reduce coordination needs and prognostic frames allow assessing the future properly.

Operational complexity: As cognitive complexity is concerned with know that, operational complexity deals with know-how, the ability to do the correct things. Again, this is a learning process and again what is of importance, are the available operational skills at the beginning of the project. These can be differentiated into technical and management skills.

3.5 Overall construct

The discussions of this chapter 3 are summarized in table 1. The table provides the construct of construction project complexity and thus complement the general definition.

Table 1: Construct of project complexity

Dimension	*Factor1*	*Factor2*	*Factor 3*	*Other factors*
Task complexity	*Elements*	*Interactions*	*Impact*	*Time pressure, space limitations*
Social complexity	*Elements*	*Interactions*	*Impact*	*Time pressure, dispersion*
Cultural complexity	*Elements*	*Interactions*	*Impact*	*Power distance, uncertainty avoidance, masculinity, individualism and long-term orientation*
Cognitive complexity	*Elements*	*Interactions*	*Impact*	*Diagnostic frames, identity frames, prognostic frames*
Operational complexity	*Elements*	*Interactions*	*Impact*	*Technical, management skills*

4. Operationalizing the construct

4.1 Developing a method to measure project complexity

The construct elaborated in chapter 3 allows measuring project complexity in the form of an index only when categories are established that can be used routinely by any one group of experts. These categories reflect the values and attitudes of those using them. Therefore, these experts must establish their own categories. This is similar to determining risk thresholds in risk management. The following categories are only an example. To this end, we propose the following categories and values for the first three factors of the construct (elements, interactions, impact):

Table 2: Categories for the factors elements, interactions, impact

Factors	*Category 1*	*Category 2*	*Category 3*	*Category 4*	*Category 5*
Value	*20*	*40*	*60*	*80*	*100*
Elements (X_1)	*few*	*average*	*Many*	*a large number*	*extreme*
Interactions (X_2)	*few*	*average*	*Many*	*a large number*	*extreme*
Impact (X_3)	*negligible*	*average*	*Strong*	*very strong*	*Extreme*
Other factors (X_i)	*negligible*	*average*	*Strong*	*very strong*	*extreme*

Finally it becomes necessary to attach a weighed to each factor so that they can be summed up to the dimensions. These are given in table 4.

Table 3: Weights for the factors

Factors	*Elements (a)*	*Interactions (b)*	*Impact (c)*	*Factor 4(d_i)*	*Sum*
Weight	*0,225*	*0,225*	*0,300*	*0,250*	*1,000*
Time pressure	*Task complexity*			*0,150*	$d_1 = 0,25$
Space limitations				*0,100*	
Time pressure	*Social complexity*			*0,100*	$d_2 = 0,25$
Dispersion				*0,150*	
Power distance	*Cultural complexity*			*0,075*	$d_3 = 0,25$
Uncertainty avoidance				*0,075*	
Masculinity				*0,033*	
Individualism				*0,033*	
Long-term orientation				*0,033*	
Diagnostic frames	*Cognitive complexity*			*0,075*	$d_4 = 0,25$
Identity frames				*0,100*	
Prognostic frames				*0,075*	
Technical skills	*Operative complexity*			*0,125*	$d_5 = 0,25$
Management skills				*0,125*	

The criteria established so far allow writing mathematical equations for the five dimensions of construction project complexity. It should be kept in mind, that while the form is mathematical, the contents are not exact and in consequence, the results are also not exact.

Complexity $_{task}$ $= C_{ta} = a * X_1 + b * X_2 + c * X_3 + d_i * X_4$

Complexity $_{social}$ $= C_{so} = a * X_1 + b * X_2 + c * X_3 + d_i * X_4$

Complexity $_{cultural}$ $= C_{cu} = a * X_1 + b * X_2 + c * X_3 + d_i * X_i$

Complexity $_{cognitive}$ $= C_{co} = a * X_1 + b * X_2 + c * X_3 + d_i * X_i$

Complexity $_{operational}$ $= C_{op} = a * X_1 + b * X_2 + c * X_3 + d_i \quad X_i$

These five equations give us values for each complexity dimension; they need to be summarized as an index, the complexity index. The procedure is again the same as before, the experts determine for each of the five dimensions a weight (v, w, x, y, z) and then calculate the index. The maximum value is 100:

Complexity index for the project i: $C_i = v * C_{ta} + w * C_{so} + x * C_{cu} + y * C_{co} + z * C_{op}$

At the very end we need a classification for the project and propose the following terminology:

Table 4: Categories for projects

Description	*Highly complex*	*Very complex*	*Moderately complex*	*Normally complex*	*Simple*
Complexity index	*100 – 80,1*	*80 – 60,1*	*60 – 40,1*	*40 – 20,1*	*20 - 0*

4.2 Determining the value of project complexity

Evidently it is not easy to determine a value for project complexity. A tested approach to such problems is to divide the overall problem in a sufficiently large number of sub-problems and to evaluate these individually. By our bounded rationality we will most often be a bit off the target. If no bias exists (i.e. we deal with a normal distribution of errors) then we will at times overestimate a value and at others underestimate another one. Overall these have a tendency to cancel each other out. This approach is for example used on a daily basis in estimating the price of construction projects around the world.

In order to increase reliability we propose to evaluate project complexity by a panel of experts. A reasonable number will be between three and five. Each expert calculates the complexity index by himself and then an average is produced that represents inter-subjectivity, the very best we can do in a non-physical world. Larger differences will of course be discussed. A reconciliation of data is not required but an understanding of why differences occur. There should be an agreement on premises.

What can we practically do with a complexity index? We can avoid disaster. There are innumerable examples of construction projects around the world where one or more parties have been overwhelmed by an unforeseen degree of complexity. It can also alert us to what set of tools we need for a specific project, what type of experiences.

5. Conclusion

We have found that the conceptualization of project complexity yields a construct that is complex by itself. This is the paradox of struggling with complexity in theory and in practice: complex problems demand complex structures as an answer. This understanding is at the core of the works of Luhmann, Weber and Parsons: In modern societies the class structure has been replaced by an ever increasing and more specialized number of functions such as politics, economics, science, religion or the different professional fields. Each function allows dealing with an unprecedented high degree of complexity in its own right. However, the overall structure of society has become much more complex and integration becomes one of the main objectives.

A second understanding is that complexity is by nature not a physical entity. Throughout we have called it a construct, clearly identifying it as a social construction. We are dealing with a social construction of reality (Berger and Luckmann 1967). This does not imply that we are leaning in general towards constructivism. We subscribe to Popper's idea of three worlds (1979): a physical world, a world of our conscious experiences and a world of logical contents. Complexity belongs to the latter two worlds. It is none the less as real as a physical entity.

As a consequence we have proposed to evaluate project complexity through a subjective expert evaluation process that is in a second step elevated to an inter-subjective appraisal by the cooperation of a number of experts. The Degree of or the identified nature of complexity can be an important criterion for a project typology capable to classify also the anticipated managerial challenges.

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A novel collaborative planning methodology for complex infrastructure design projects

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Abstract

The design of complex infrastructure projects requires inputs from a complex set of interconnected disciplines. If it progresses without sufficient information it can evolve in an inappropriate direction and can lead to downstream problems and re-work. Collaboration has been identified as a crucial enabler of effective design and can have great effects on the final design performance of the completed asset. However, the design phase is frequently late, exhibits low programme predictability and has been identified as an area in need of improvement and greater control. Traditional project management techniques are reported to be insufficient to deal with the increasing complex nature of construction and engineering projects. Furthermore, process knowledge fails to be captured resulting in deficient cross project learning. The purpose of this research is to identify how collaborative planning can be developed to support such design processes and to test these within live project environments.

Following an extensive literature review, a series of collaborative planning meetings were organised for those involved in highways design activities. These meetings were structured and facilitated in such a way as to reveal issues which could have led to design inefficiencies. Weekly observations were made over a four month period with the team members of nine design schemes in order to examine the factors which enabled and inhibited the development of effective design solutions.

The collaborative planning process revealed deviations from the standard process procedures resulting in process discontinuities, negative design iterations, wasted opportunities and inefficient use of resources. As the collaboration was structured through the workshops it was possible to further reconfigure the design process and realise benefits in terms of programme predictability. Visual aids proved to be to be a powerful way of understanding how objects can enable multifarious people to mutually understand a process.

The research demonstrates how collaborative planning, augmented with process mapping, can yield process performance and increase programme predictability of large scale highways maintenance schemes. However, results indicate that the act of bringing people together to collaboratively plan their work is not an end in itself but the catalyst for other necessary changes. The findings provide a point of departure for research which seeks to develop strategies for managing design input for major highways infrastructure schemes.

Keywords: Collaboration, Highway design, Infrastructure, Lean, Process improvement

1. Introduction

Construction is a project based industry with a highly complex, fragmented and uncertain operating environment (Fearne and Fowler, 2006). Characteristics which set it apart from manufacturing are on-site production, one-of-a-kind products delivered through a web of highly complex and complicated activities (Koskela, 1992). The fragmented nature of the industry and the placement of responsibilities for design, fabrication, assembly and production with different organisations with their own separate objectives lies at the root of many of the industry's problems (Mitchell et al., 2011, Austin et al., 2001); indeed it is these characteristics that pose barriers to innovation (Koskela and Vrijhoef, 2000). Within complex infrastructure projects the need to coordinate disparate inputs throughout the project lifecycle are particularly acute (Hodgson and Cicmil, 2006, Winch, 2010). In particular, the efficient coordination of multiple design inputs in the design phase and the management of uncertainty pose particular challenges (Lawrence and Scanlan, 2007, Williams, 2002).

Design is a critical factor for business success (Yin et al., 2011) and there is a significant body of research dedicated to collaborative design performance (Mitchell et al., 2011, Yin et al., 2011, Baldwin et al., 1999, Austin et al., 2007). But for lean construction, lean design is considerably less discussed or researched and is as equally ill-defined as lean construction (Jorgensen and Emmitt, 2009). There is a lack of underlying theories for design (Mitchell et al., 2011) or construction (Koskela and Vrijhoef, 2000). In the literature it is not clear whether "lean design", "lean design management" or "design for lean construction" are or are not the same phenomena (Jorgensen and Emmitt, 2009). However, the main lean principles of increasing value for the customer and the elimination of waste from the system remain the same.

This research investigates how aspects of lean thinking can help improve the design phase of complex infrastructure projects with particular focus on how the collaborative planning process should be developed to account for the specificities of highways design. Within the UK, the Highways Agency (HA) has realigned its procurement strategy following recommendations made by major studies since the late 1990s to take into account partnering and framework contracts (Wolbers et al., 2005). The last two years have seen the HA increase pressure to see lean implemented throughout its supply chain, with the roll out of HALMAT to assess lean maturity (Highways Agency, 2010). However, fragmentation between design and production is problematic (Jorgensen and Emmitt, 2009) and there is a need for greater integration of the programming of design and construction processes (Jorgensen and Emmitt, 2009, Egan, 1998). Contractual and organisation efforts have been made to integrate the fragmented responsibilities of construction resulting in multiple layers of contractual agreements within single projects to protect the various stakeholders, further reinforcing the image of an industry characterised by a lack of trust and adversarial practices (Fearne and Fowler, 2006, Egan, 1998, Latham, 1994). Developing ways to manage the collaborative planning process arguably provides a crucial first step in ensuring more efficient and effective design of such projects.

2. The application of lean thinking in complex infrastructure design projects

Value is delivered on site but it is created in design (Zimina and Pasquire, 2011). However, although detailed design interfaces with the construction process, efforts to improve design have tended to view it in isolation (Mitchell et al., 2011). This might be because the iterative nature of design contrasts with the linear nature of construction and makes the interface between the two phases complex and difficult to manage. Increasing pressure to integrate the design and construction phases (Egan, 1998) results in information being drawn from design before it has reached appropriate maturity in order to drive procurement (Mitchell et al., 2011). It is important, therefore, that information inputs are timed to meet the needs of other participants in the design process in order to efficiently and effectively produce the design deliverables (Baldwin et al., 1999). The problem comes with recognising the optimum time to provide the necessary information. Design rarely has a conclusion and instead it is improved until a deadline is reached (Mitchell et al., 2011). Thus, from the waste/value understanding of lean, design iterations create a lot of "waste" in the form of drafting, rework and time spent on options that are later decided against (Jorgensen and Emmitt, 2009, Highways Agency, 2010). The challenge to managing design is to enable positive design iteration (whilst avoiding negative iterations) and ensure crucial parameters are not fixed too soon to prevent positive improvements but are fixed early enough for the design process to progress (Jorgensen and Emmitt, 2009).

It was competition from the Japanese production market, particularly in the car industry, that was the impetus for the West to research Japanese methods (Green, 1999), leading to the publication of The Machine that Changed the World (Womack et al., 1990). Since the 1990s lean has become increasingly prominent in construction heavily influenced by the management and production debate (Jorgensen and Emmitt, 2009). Whilst Lean began in the manufacturing sector, most famously with Toyota, it can be just as effective applied to administrative and office processes (Mann, 2010). An application of Lean principles to the design process can significantly help to improve process efficiency and the outcomes of the application of simulation modelling and lean principles in the construction industry are reported to be outstanding (Marzouk et al., 2011).

Current Lean literature makes efforts to point out that lean is not a set of tools for implementation but a long term strategy, a new way of thinking and a never ending search for a better way (Liker, 2004). However, many examples of implementation fail to spell out what the ethos of lean is and how it can be attained. It is too "soft" to explain and attention is instead diverted to lean tools and techniques where it is easier to demonstrate and quantify lean implementation. Rather than shy away from these soft issues, it is crucial that Lean research turns its attention to better understanding how and why the softer interpersonal and behavioural issues affect project management and design delivery.

In a project-based environment, it is normal practice for different people to be doing different things in different places at different times for different organisations, often working simultaneously on different projects. The 'silo-like' mentality that is all too often present makes the flow of information across these divides problematic (Tribelsky and Sacks, 2011). The construction industry is characterised by little problem solving in groups, a lack of suggestion schemes, few employee surveys and a culture where human resources are seen as a cost to the business (Green, 2002). The failure to address the softer issues continues with project management literature which is dominated by tools and techniques (Green, 2006) and by prescriptive assumptions focussing on project organisation (Ivory et al., 2006).

Whilst there is little research concerning highway construction and infrastructure maintenance, there is much research concerning collaborative working, frameworks and evidence to suggest successes, although, evidence of the long term performance of framework agreements is lacking (Ansell, 2009c). The last decade has seen an increase in examples of collaborative working (Tennant and Fernie, 2010). Whilst it can be said that collaborative working, integration and lean are not meaningfully defined (Green, 2011), we can say that collaboration is not just about sharing information (Jorgensen and Emmitt, 2009). Collaborative planning could provide a useful technique for bringing together representatives of all parties' onsite activity to commit to improve programme reliability and increase productivity (Highways Agency, 2010).

3. The role of collaborative planning and collective learning in highways design

Research has indicated that the planning and coordination of fragmented tasks to improve productivity can be achieved through collaborative planning and the application of the Last Planner system of production control (Ballard, 2000). Last Planner is a key lean project management method, originated in 1992 (Ballard and Tommelein, 2012) and is immediately relevant to the challenges faced by the industry (Green, 2011). A benefit of Last Planner is that it can be easily combined with existing practices making it a good first step on the long lean journey, but all aspects of the principles of Last Planner must be followed through if maximum effect is to be realised. As a technique for improving project performance, Last Planner has been successfully applied to construction and design phases of construction projects (Ballard, 2002), but the benefits reported are isolated to the project in question. Ballard (ibid.) suggests further work should be undertaken to categorise reasons to facilitate the implementation of the learning process, including the recording of results. However, although he identifies a failure to learn from plan failures and failure to implement a learning process, he does not allude to what such a learning process would, or should, look like; something that the collaborative planning process could be developed to include.

Second generation perspectives on knowledge management reveal how although some knowledge is possessed, made explicit and transferred from one person to another, other knowledge is embedded in practice and must be shared through dialogue and social networks (Newell et al., 2006). In other words, the interface between design and construction is largely social, involving people and their interactions (Mitchell et al., 2011). Project teams assume that knowledge can be captured and transferred unproblematically using ICT (Newell et al., 2006). In practice, knowledge traverses the divide and it is vital therefore to understand which forms of knowledge are possessed and which are embedded in order to share them effectively between people and across projects (Newell et al., 2006). Collaborative planning arguably provides a social networking opportunity through open dialogue and therefore lends itself well to the transfer of knowledge that is concerned with processes as opposed to the product; the whys and ‘hows’ rather than the ‘whats’ (Newell et al., 2006). It is important to know what and when things are needed but also why they are required (Terry and Smith, 2011). Gaining an understanding of the “why” is where collaborative planning is essential for lean thinking. A genuine understanding of value leads to a genuine understanding of what is not of value. Others would add that knowledge of the project, client user and stakeholder value, are likely to be insufficient for effective collaborative design and construction without a deeper understanding of the underlying contextual circumstances that define value (Jorgensen and Emmitt, 2009). However, research has shown that the “softer” issues surrounding human interaction are not appreciated or ignored during project reviews (Newell et al., 2006). The most challenging part of Last Planner is to learn from plan failures (Ballard and Tommelein, 2012) and learning from failure must come in the form of understanding why people did what they did, and not an establishment of what they should have been done (Dekker, 2006).

Projects are referred to in terms of their deliverables (product knowledge) rather than the way the project was developed and managed (process knowledge) (Newell et al., 2006). Focussing on process is essential for lean success (Mann, 2010). But, product knowledge rather than process knowledge is what is captured at the end of a project. Newell (2006) argues this is due the concentration on delivering the project objectives to target with no consideration for the benefits for the wider organisation. The focus is often on short-term objectives that fail to recognise the need for long term organisational relationships (Austin et al., 2007). Where work is predominantly project based it is vital that an understanding of organisational knowledge is developed (Bresnen et al., 2004), especially if cross project learning is to be successful. It is here that collaborative planning could play a significant role in enabling knowledge flows around the design process.

4. Methodology

The study reported here was an exploratory investigation of nine highways schemes in the design phase in the UK. The study was aimed at understanding how the application of collaborative planning techniques could improve the performance of highway design and could promote learning across the organisations and disciplines involved.

The research comprises a single-case with multiple embedded units of analysis, chosen to represent typical projects undertaken by the organisation. Although some criticism is levelled at case study research (Yin, 2009) the value of this methodology lies in the collection of rich empirical data and a deep understanding of the context brought about through participant observation over a period of four months. While the findings are specific to the organisation in question, the results offer the opportunity to generalise to broader theoretical positions around the wider application of collaborative planning that tends to be overlooked in the extant literature.

Due to constraints, the details of each and every scheme of the collaborative planning process cannot be presented here. Instead, salient points to demonstrate particular issues have been drawn upon. The projects were chosen to give representation across the disciplines of roads, structures and small network renewal schemes. These projects embody the complex inter-professional (highways, environmental, drainage, structures, traffic management, geotechnical and the like) working relationships found in project based organisations. The team members were working on numerous projects simultaneously and with different team compositions. Adding to the complexity was the geographically diverse design teams distributed across offices in Central England, Scotland, Southern England and Northern Ireland. Spatial organisation was further complicated with liaison between design and construction/operational teams that are based in depots situated around the road network. Members of the reams rarely, or never, met face to face and there was a tendency not to pick up the phone to discuss issues with geographically dispersed team members.

The research was conducted within an action research framework (Naoum, 2007, McNiff, 2002) where weekly collaborative planning sessions were established with the nine schemes and the data gathered through participant observation. This ethnographic and phenomenological approach permitted an insight into the inner workings of project teams whilst enabling a rich understanding of the meanings and interpretations of social interactions. Using an external facilitator/consultant to manage the collaborative planning process, each scheme (of between 3 and 10 team members) met for 20-30 minutes each Monday to review and record tasks set the previous week as complete or incomplete. A percentage plan complete (PPC) score was assigned based on tasks completed divided by the number of tasks planned for completion, expressed as a percentage. Reasons were captured for any non-completion and a fresh list of tasks was set for the following working week. The discussions were recorded and the impacts on the design process evaluated, as well as the implications from cross-disciplinary learning.

5. Findings and discussion

Throughout the observation period the issues challenges and opportunities that emerged tended to fall into one of three themes: collaboration, reliability and process deviation, each of which is now discussed in turn.

5.1 Collaboration and intra-group dynamics

Many of the schemes observed during this study brought together for the first time team members who had not previously met face to face or via telephone to collaboratively plan project work. Researcher participation at approximately 90 hours of planning sessions allowed the observation of interesting team dynamics. It was clear from the outset that an individual’s job title often did not correspond with the individual’s behaviour. Team leaders were not necessarily the individuals who lead the teams during collaborative planning sessions. For example, programming was highlighted as an area of weakness amongst all project teams. Each team possessed a Team Leader and a Project Manager. The Project Manager, as one might expect, should be responsible for managing the project. However, it was the Team Leader’s responsibility to own the design programme. In collaborative sessions tasked with planning work this led to confusion and lack of ownership and accountability of the process. The result was no one taking the lead. For collaborative planning to work effectively people need clearly defined job roles. The collaborative planning process could be developed to assign clear roles for the collaborative planning sessions in addition to professional roles and give responsibility to members to carry out regular tasks such as ensuring programmes are brought to planning meetings and organising representation of appropriate members of the project team. Doing so would enable the collaborative planning technique to further support ownership and leadership.

Project ownership was observed as a problem area and interviews allowed further probing. *"Programming is not taught in civil engineering degrees", "I'm not a programmer...the programme I put together is based on a template"* and *"programme or no programme, everyone knows what should be done and when"* are examples illustrating the low regard Team Leaders have for programming. During the earlier collaborative planning sessions, Team Leaders and Project Managers attended planning meetings without a programme for reference. When asked to bring programmes to future meetings it transpired that programmes had not been developed; it was many weeks into the process before teams began to take ownership of the process.

When asked about the time required to conduct collaborative planning sessions the response from one manager was: *"the time commitment is good, it needs to be done...but some [team leaders] are paying lip service...they still need to understand the bigger picture of programming stuff...they don't seem to understand that you have to give people time to programme their own work...got to sit down and think who your teams going to be whether they have a small part or a big part, they need to be there from day one...they need a heads up that we'll need your services in x months' time...they don't seem to grasp the idea of working as a team...they see it as a failure if they have to ask for help".* Getting the mind-set right is easy to say but difficult to do. *"Attitude since the start of this commission...it has been difficult for them to feel a belonging to [the commission]...before you were in the depots and part of [the commission] in one office everyone together...Now because we are part of consultancy there is no feeling of belonging...lost a sense of belonging to part and parcel of the team...the commitment is there but the sense of belonging is lost...two and half years later and it still bugs them that they are not part of [the commission"].*

As with lean manufacturing, lean in the office meets resistance but Mann (2010) argues that background to the resistance is different. Measuring actual versus expected output in an office is not straightforward and office workers are not used to being held accountable to the same extent as production workers in manufacturing, partly because around half an office workers time is spent on non-value adding tasks such as corrections and waiting for information. In support of this assertion, analysis of the tasks on the weekly production plans during the collaborative planning sessions revealed that for some schemes, 54% of tasks were related to design with only 38% being purely design work. Therefore between 46% and 62% of tasks were non-design (non-value-adding) but related to project management and project administration, such as arranging and attending meetings and chasing paperwork. Planning collaboratively does not automatically fix this but it enables the issues to be driven to the surface by giving project teams the tools to collect the data required to see. During interviews, Managers said this is having positive effect on teams.

Intermediaries are able to encourage teams to see how they can learn from others (Newell et al., 2006). Intermediaries naturally emerged in the collaborative planning sessions as they were able to see the cross project learning opportunities arise and offer their knowledge. It is unlikely that this knowledge would have been asked for, or known to exist. Managers need to focus on the management of meaning and take seriously their role as interpreters (Ivory et al., 2006). Collaborative planning can facilitate project level learning which is crucial for the transfer of process knowledge and the softer issues that cannot be represented by a drawing or be transferred via ICT (Newell et al., 2006). The collaborative planning process should be developed to identify these individuals and ensure their attendance.

The role of the facilitator in the collaborative planning sessions cannot be underestimated or their impact ignored. At the outset, team members asked the external consultant for their experiences of undertaking collaborative planning with other clients. The past experience of the facilitator helped give confidence to sceptical members that this process had been tried and tested and worked in the past to bring benefits. Somewhat contradictory to this is that an external facilitator brings with them a healthy amount of naivety in relation to the inner workings of the organisation. This was utilised to help to draw out underlying issues. Unfamiliarity between the design teams and external facilitator added to the novelty of the process and aided buy-in during the early stages. The alternative would be to facilitate the sessions using in-house resources.

5.2 Collaborative planning and process reliability

At each weekly collaborative planning meeting, the percentage plan complete (PPC) was tracked and reasons for non-completion captured. Average PPC over 15 weeks of collaborative planning sessions was 70%, consistent with other similar studies (Ansell et al., 2007). As non-completion lessens, PPC increases leading to ‘improvement in productivity, quality, timeliness, safety and other dimensions of project performance’ (Ballard, 1994). Observations made during this study indicated that an increased PPC score does not necessarily correspond to improved productivity. The act of bringing people together to collaboratively plan their work is not an end in itself but the catalyst for other necessary changes.

The collaborative planning sessions were found to bring a level of accountability that was otherwise absent but the process required a high level of trust amongst participants to set realistic tasks. Observation of the sessions revealed that the process lacks control. For example, individuals were not prevented from selecting tasks out of sequence; it was left up to individuals to choose what work they do or do not do. Some flexibility on the part of the designer is necessary due to the iterative nature of the creative design process, but a haphazard ordering of work tasks can result in undesirable negative iterations. This again brings into question the role of team leaders and project managers. Collaborative planning sessions were reported to have *“opened their mind and concentrates what they do in the week...we need to make sure we do it and push it forward...team leaders should be pushing it”*. However, some teams are working under team leaders who *“instead of spending 10 minutes finding a solution they’d rather spend 20 minutes writing a 4 page email of why it can’t be done...we’re trying to change their mentality...they need training in being team leaders...not having enough resources has put major pressure on them because they’ve got to do the work as well so they can’t be proper team leaders”*. It became clear that running collaborative planning sessions each week was not sufficient to radically change the pre-existing working practices. The process must be supported with appropriate training to enable leaders to lead. A deficiency in skills to programme effectively has been emphasised. To overcome this it is felt that the collaborative planning process must become more robust to better communicate the wider need for planning.

Weekly dashboards were created to visually display the results of the collaborative planning pilot. The dashboard included a graph depicting the PPC scores and a line illustrating the trend in the scores. This sparked many comments and much debate and highlighted the power of visual management. For some teams, maintaining a positive trend line was more critical than using the sessions to plan tasks to enable downstream work. At the outset, the facilitator predicted that the creation of peer pressure at meetings would fuel commitment. This happened to an extent. More noticeable were team leaders questioning whether the tasks being set were achievable within the week before the next collaborative planning session to prevent low PPC scores rather than to make ready future work. The peer pressure and competition observed was between teams and not within teams as predicted. But this tended to encourage the wrong behaviour. The Last Planner motivation for setting weekly tasks is to ensure readiness of work to enable the progression of downstream tasks. Instead some teams set tasks on the basis of work they were confident of completing to ensure high PPC scores, with no regard for making ready future work. This is a factor requiring attention when developing the collaborative planning technique.

5.3 Collaborative planning and process improvement

The primary reasons for non-completion of tasks were similar to those found in related studies (Ballard, 2002) with 151 of the 283 reasons stated for non-completion of work tasks attributable to unavailability of pre-requisite work. When capturing reasons, a distinction was made between unavailability of internal (97 instances) and third party (54 instances) pre-requisite. The high frequency of pre-requisite information cited as the reason preventing the completion of weekly work tasks highlights the ineffective handover of information indicating a problem with the process.

Reviews with the client form gateways in the process designed to capture information about design progress to date and ensure necessary paperwork and approvals are in place before the scheme progresses to the next stage of design. Deadlines and milestones naturally divert attention to the product knowledge (Newell et al., 2006), however it is the process knowledge concerned with the how and why that enables learning, which is supported by the collaborative planning process. In many cases, the pressures on designers do not arise from the drive to integrate with construction, but are due to compression of the time “allowed” for design development. As a result, design iterations continue to evolve in a way that is potentially inappropriate due to lack of specialist input. Common causes of problems are starting design tasks too early based on assumed information and releasing design information in batches (Baldwin et al., 1999), both of which were observed in this study. Whiteboards were used to display the standard process and magnets tracked schemes as they progressed through the gateways. Doing so highlighted deviations from the standard process and instances of negative design iteration. For example, a scheme was held at Gateway 1 awaiting client sign off. Rather than obey the hold point and wait, the design team continued to schedule tasks for the stages between Gateway 1 and 2. Should the client decide to change the scope of works as part of the Gateway 1 review, any design work completed out of sequence would be rendered useless. By mapping the actual process against the standard process it was possible to identify discontinuities and highlight areas where the process was failing to support project delivery. The decision could then be taken to reengineer the process to better suit project delivery, or modify work practices to adhere to the process. Either way, collaborative planning coupled with process mapping enabled the capture of process knowledge; information about how and why a project is delivered the way it is. Even before any re-engineering of the process takes place, significant leaning has taken place in recognising deviation from process and the pitfalls this brings.

The white boards worked well to support the collaborative planning process as they created a visual aid and provided an "at a glance" understanding of where in the process the scheme was. In this way, the whiteboards acted as both a sense giving tool (Ivory et al., 2006), promoting the urgency and importance of the projects and as a 'boundary object' (Star and Griesemer, 1989) in the ways in which it enabled translation of meaning across communities. Ivory (2006) warns that it is possible for pre-existing discourses to be too well entrenched for sense giving tools to have much impact. Through observations made, this is felt to be a significant issue that is all too easy to overlook. The collaborative planning process needs to consider the embedded "business as usual" attitudes. Although the white board process mapping clearly illustrated the deviation from process and out of sequence working, teams made no efforts to develop a solution. The collaborative planning participants need support from team leaders to encourage continuous learning and feel empowered to challenge barriers.

6. Conclusions

This research aimed to examine how collaborative planning combined with process mapping can lead to improvements in performance and programme predictability during design. As is discussed above, the benefits of coming together to collaboratively plan project work are well documented. Less well covered in literature surrounding lean and collaborative planning is the "soft" issues and the wider implications these have for the organisation. Collaborative planning is largely a social interaction, enabling the improved flow of information and greater understanding of the process. However, carefully facilitated, it has shown how the collaborative planning process can reveal deviations from design process protocols identify negative iterations and highlight opportunities for improvement. However, the collaborative planning process also requires significant development if it is to take account of the specificities of complex infrastructure design environments. For example, it should be developed to include process mapping and process tracking as an integral part of the collaborative planning process to enable the capture of process knowledge. Doing so would build significantly upon the analysis of reasons for PPC failure by highlighting deviation from the accepted process and provide the evidence required to either reengineer the process to better support the delivery of design or inform a change in working practice to ensure adherence to the process. It is also clear that individuals require clearly defined roles and that training is required to support team leaders to become better leaders and to enable them to support their teams to improve. Perhaps the most significant enabler of effective collaborative planning concerned the use of visual cues. The white boards were a powerful tool through which to coalesce the inputs of the actors and to provide a basis for common understanding. The major challenge going forward is to develop the collaborative planning process to account for the more subtle behavioural aspects that carry the potential to affect the consistent realisation of collaborative planning benefits implementation. The approach must be developed in order that it can account for these nuances, but without prescribing rigid and normative approaches that could serve to stymie both the creativity of designers as well as broader learning opportunities.

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Has partnering worked in the UK water sector? An analysis of a partnering relationship between a leading UK water provider and their contractor

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Abstract

Partnering, as a procurement strategy, has been embraced by the UK construction industry as a whole. However, in the context of the UK water sector, although partnering has been adopted, there is little empirical research to demonstrate whether it actually achieves the proclaimed benefits. This paper analyses an Client : main Contractor five year framework agreement, providing an up to date insight into whether partnering has been a success within this part of the industry. Through undertaking a thorough review of existing partnering literature, the prominent partnering characteristics and benefits were identified in addition to the associated limitations. Three semi-structured interviews were conducted with senior management of a leading UK water provider and one of their partnering Contractors to establish the extent to which the prominent partnering characteristics had been embraced within their framework agreement, and whether the benefits had been obtained and whether the limitations were apparent. The analysis of the data revealed that the majority of partnering characteristics had been embraced, with many benefits realised. The limitations were also evident, but these were mitigated through the use of a 'bigger picture' perspective in assessing issues that had become manifested throughout the framework. The 'bigger picture' perspective facilitated the success of the relationship and overall framework result. In concluding, although proposals for improvement were put forward, partnering has worked in the water sector and the project outcomes have been positively influenced through the implementation of partnering.

Keywords: Partnering, Procurement, UK Water Sector

1. Introduction

Partnering was introduced into the construction industry in the 1990's after the industry had attracted criticism for having systematic failings and fostering an adversarial environment. In his report, Egan (1998) suggested that partnering had the potential to make construction contracts obsolete, with the anticipated success resting on the implied covenant of good faith. Since then, there have been a plethora of studies with many practitioners promoting or discussing the benefits that partnering can achieve (Bennett and Jayes, 1998; Bennett and Peace, 2006; Brookes, 2008). However, other reports have highlighted some problems (Black et al., 2000; Brookes, 2008; Hirst, 2009); although Brookes (2008) and Hirst (2009) suggest that there has been an encouraging uptake of the partnering philosophy.

One major sector of the construction industry which has implemented partnering is the water sector. This paper will analyse the effect that partnering has had upon this sector, specifically looking at the relationship between the Client and one of their construction partners on one framework. This provides a unique insight into an example of partnering in use within the specific context of the UK water sector and explores whether the partnering principles have been truly adhered to and whether any have been overlooked. Additionally, this study will ascertain the reported benefits of partnering and to establish if any limitations are evident. The findings can then be used to explore whether partnering could facilitate the water sector in accomplishing the better relationships and project outcomes to which Latham (1994) and Egan (1998) aspired. As a single case study, this paper cannot answer the key question of whether partnering can work in the water sector. Nevertheless a fresh outlook is offered to existing literature, which can be used as a basis for further research with different partnering relationships within this sector and other sectors, both nationally and internationally.

The Client in this paper is a water company who frequently undertakes work to ensure that their water and sewage treatment works, processes and products comply with EU regulations. The majority of their construction work is allocated to a small number of main Contractors under a framework that runs for five years, in which the selected main Contractors are guaranteed a certain level of turnover. This paper focuses on a framework which ran from 2005 to 2010, whereby works to upgrade and renew water and sewage treatment work to the value of £90 million were planned. The Contractor is a UK construction, infrastructure and design business, within both the private and public sectors and has worked on other frameworks with this Client. In order to give the Client cost certainty, the framework in this case study principally centred on the notions of a design freeze and a fixed price based upon an initial outline design. A wealth of cost information has been recorded over the years and this was used in agreeing the fixed price with the main Contractors.

Two terms that are referred to in this research paper are 'standard items' and 'cost curves'. A standard item is a structure that has been built in previous frameworks and, when they occur, the price for these is dictated by the cost curve, which is a line graph illustrating the final cost for each specific standard item that was built over the previous frameworks.

Although partnering literature is ubiquitous there is very little, if any, concentrating solely on the UK water sector. This paper will therefore provide a unique insight into the effect that the partnering approach has had within one UK water project framework, in addition to identifying the extent in which a major construction Client in this sector has embraced the partnering philosophy.

The paper is structured as follows: background, research method, results, discussion and conclusion.

2. Background

There is a wealth of available literature regarding partnering and its implementation, and their consistent themes and recommendations are well known (Latham, 1994; Egan, 1998; Bennett and Jayes, 1998). Undoubtedly 'The Latham Report' (Latham, 1994) and 'Rethinking Construction' (Egan, 1998) remain the landmark papers, in which the need to address deep-seated problems within the industry was discussed and with recommendations that the entire construction process should become customer and quality focused, more cost effective and profitable, and more collaborative with long term relationships becoming the norm where possible. The Client was urged to lead the change towards an improved UK construction industry, with a view to eliminating its adversarial nature. Although the fundamental characteristics that exemplify this ethos are well documented, it is necessary for the purpose of this paper to briefly restate them.

Cheung et al. (2003) recommend the use of a partnering charter which, according to OGC (2003) sets out and agrees 'the principles, attitudes and ideals that will characterise the arrangement'. Many authors (Bresnen and Marshall, 2000a & 2000b; OGC, 2003) allude to the use of pain-gain and profit share with the use of Key Performance Indicators (KPIs), with Yeung et al. (2007) identifying KPIs in terms of time, cost and quality, innovation, effective communication, management commitment and trust and respect. However Bresnen and Marshall (2000b, p596) state that not only can KPI scoring systems be subjective, but their findings 'cast doubt upon the simplistic presumption that there is a necessary and direct relationship between project incentives and performance outcomes'. Additionally, the pain-gain ratio can vary from project to project, with some Clients not allowing the Contractor to take any gain share (Wood, 2005). Shared risk is said by many to be an advantage (Cheung, 2002; OGC, 2003; Brookes, 2008) with Hirst (2009) stating that shared risk and reward is the key to partnering and Cheung et al (2002, p364) saying that 'joint risk management is fundamental in partnering'. However, Dartnell (2007) advises that Clients do not always wish to accept their share of risk, and Brookes (2008) observes that Clients see partnering as a means of transferring risk.

Conflict resolution and dispute avoidance are seen as one of the essential ingredients of a partnering arrangement (Cheung et al (2002); Hibberd (2007)). This can be aided by means of continuous evaluation, which is a procedural characteristic pertinent to the partnering ethos with Bennett and Jayes (1995) believing that regular in-process reviews are paramount to the success of a partnering agreement as they are a means of appraising whether set goals and objectives are being achieved. However, Ball and Chambers (2009) advise that performances measures, including KPIs, are only effective if constructors are truly engaged in collaborative working. Many commentators believe that a long term commitment is required for partnering to prosper (Cheung et al., 2003; Kaluarachchi and Jones, 2007) and that mutual objectives must be agreed so that a win:win attitude (Fleett, 1996) can be adopted together with the notion of equity and equality (Bennett and Jayes, (1998). Black et al. (2000, p432) reported that their ‘respondents do not believe that there is an equitable sharing of the benefits which are derived from the use of partnering’. Subsequently, in order for mutual objectives and a win:win attitude to exist, mutual trust is essential and is also deemed to be a key characteristic of partnering (Black et al., 2000; OGC, 2003; Kaluarachchi and Jones, 2007). Despite this, OGC (2003) warn that trust needs to be developed and earned through the right actions, behaviours and performance otherwise the relationship is liable to break down. However, Brookes (2008, p325) believes that it is “naive to think that organisations ... within the industry will ever truly trust one another” and Bennett and Peace (2006) advise that the use of ‘open book’ accounting could be interpreted as a lack of trust towards the main Contractor. Cost savings are an acknowledged benefit of partnering. Albanese (1994) attributes better cost performance to the alleviation of rework, increased involvement of team members, eliminating problems with scope definition, lowering change order rates, a better understanding of project objectives and a desire to avoid conflict. Savings in time and money are achieved through a shortened period of procurement, a regular flow of work for the Contractor (Hirst, 2009) and early Contractor involvement allowing design and construction to be overlapped (Emsley, 2005).

However, disadvantages to partnering have been identified. Problems include distrust, uneven commitment, and a lack of open and honest communication, a reluctance to move away from a win:lose mentality, an unwillingness to compromise and a general lack of understanding of the partnering philosophy. The parties must adhere to the principal partnering characteristics in order for it to be successful (Ng et al., 2002). Bennett and Peace (2006, p12) support this stance by stating that ‘partnering is not an easy option ... it has to be worked at by everyone involved to achieve the full benefits’. Often the benefits emanating from a partnered project are attributed to partnering when other factors may have been significant. Additionally, much of the literature concentrates on successful examples of partnering based upon exemplar organisations (Bresnen and Marshall (2000a); Wood (2005)) which means that some claims made, such as those by Bennett and Jayes (1998) who promote up to 60% cost savings and 80% time savings, need to be seen as exemplary rather than the norm, particularly as the benchmarks against which both cost and time savings are measured are rarely given.

3. Research Method

In an attempt to collate robust data it was imperative that a balanced representation from each side was obtained and it was felt that senior managers would provide more insightful data as they are heavily involved in the procurement, direction and maintenance of business relationships and are, therefore, ultimately responsible for ensuring that the delicate and complex issues that manifest themselves in construction projects are dealt with appropriately. Consequently, the Contractor’s Framework Director and Managing Quantity Surveyor were selected, as was the Client’s Asset Creation Delivery Manager. The benefits of conducting semi-structured interviews were that it enabled the probing of answers to attain richness and a deeper overall understanding of partnering relationships within today's water sector.

The interviews were predominantly governed by a theoretical framework which centred on the individual partnering characteristic that had been identified, the partnering charter, KPI's, pain / gain mechanism and risk sharing. In addition if any characteristics were not evident, an explanation was sought to explain why they had been overlooked. There are contrasting opinions in the literature as to how important and significant each of these characteristics is in achieving success. Comparing the extent in which these characteristics had been embraced with the relevant success of the framework helps clarify the significance of each characteristic within the context of this sector. Associated ancillary questions were asked regarding the underlying principles of each of the contractual and procedural characteristics, whether such features were evident in practice, the level of importance attributed to them and how they had operated so that an assessment could be made regarding the impact of the specific characteristics on the partnering agreement. Additionally, the reviewed literature revealed a number of benefits and limitations of partnering. Participants were asked whether such benefits had been achieved and the extent to which they felt that such benefits could be attributed to the adoption of a partnering approach. Similarly, it was asked whether any of the limitations were evident. This was to assess the impact of the overall partnering approach within the water sector. Lastly, participants were asked whether they could propose any improvements that would benefit future frameworks and the partnering approach in general.

4. Results

4.1 Partnering Characteristics

Despite its acknowledged importance (Cheung et al. (2003), there was no partnering charter in place. The Client, in particular, believed that it was not necessary to have one as the long, established relationship between the parties was sufficient to solve the problems that arose. However other characteristics of partnering were adopted and this particular framework centred on seven KPIs, - Price, Time, Quality, Health and Safety, Environmental, Client Satisfaction and Third Party Satisfaction. Although both parties stated that the KPIs were not abused, the Contractor confessed that there were instances where they would put forward counter arguments and mitigating circumstances in an attempt to overturn a 'failed' KPI. In addition, where the Client's actions or lack of action had impacted the completion date, they would acknowledge that and still award the KPI. The Contractor believed that the KPIs improved the project outcome, particularly the time, cost and quality elements. Although it was accepted that one of the KPIs (Client satisfaction) was subjective, agreeing with Bresnen and Marshall (2000b), it was not considered to be an issue by either party, especially as the Client had shown flexibility in awarding 'failed' KPIs for extenuating circumstances.

In this agreement, the pain-gain share was 100% pain and 50% gain to the Contractor, based on the difference between the actual cost and the works order value. In order to obtain the 50% gain, all seven KPI's had to be achieved. Where projects produced a saving but achieved less than 7 KPI's, the saving would enter a ‘pain pot’ which was distributed at the end of each year to all Contractors in the framework who had entered pain on individual projects that year. The amount each Contractor received from the pot was dependent on the overall number of successful KPI’s each had achieved over the course of that year. In addition, the water company placed any gain share that they had received into the Contractor’s ‘pain pot’. This meant that the Clients always spent 100% of the agreed fixed price and did not actually gain from any project. This complements the fact that Contractors are exposed to 100% pain, even though the price is fixed and isn’t increased even when the scope of work increases but does represent a Client proactively adopting a true partnering attitude in respect of rewarding the Contractor for high performance. However, there were a small number of projects, where the scope of work reduced, and the full, initial fixed price remained in place. In terms of managing risk, the Client felt that, over a five year framework, there were ‘swings and roundabouts’ and that overall it balanced out financially and operationally. Technically, the fact that risk was not explicitly shared means that this specific partnering agreement did not fully embrace the ‘shared risk’ partnering characteristic, as detailed by Cheung (2002), OGC (2003) and Brookes (2008), although the mechanisms that were implemented as an alternative appear to have been successful over the five year period.

4.2 Conflict Resolution

In this framework, there was no formal conflict resolution in place despite the recommendations of Cheung et al (2002) and Hibberd (2007). However, where conflicts had surfaced, the primary course of action was to discuss the situation face to face in a true partnering approach. Although not formally defined, a ‘problem escalation ladder’ was evident but this occurred naturally rather than being an agreed process. It was felt that having worked over many years in various frameworks, there was an understanding and a way of working between the two parties that was enough to resolve matters. The Client emphasised that the ‘bigger picture’ is of prime importance and that to assess the framework as a five year programme as opposed to a number of individual projects ensured no litigation or serious conflict occurred during the whole period. This is in line with the findings of Cheung et al., (2003) Kaluarachchi and Jones (2007).

Bennett and Bennett and Jayes (1995) found regular reviews were of prime importance to the success of a partnered project, and this study has found that continuous evaluation was undertaken on both an individual project basis and on a relationship level. The project evaluation consisted of a review at three stages - start up, intermediate and post project; KPI scoring; quality assurance teams and workshops. The primary aim of the evaluation was to identify what went well, what went wrong, what can be learnt and taken forward, focussing on one-to-ones between the operational management of the two parties, continual engagement and sharing of ideas. This was deemed to be effective with both parties stating that long term commitment was demonstrated through the five year framework agreement as it gave relationships the opportunity to develop. There were formal mutual goals and objectives by means of an ‘integrated delivery plan’, which was produced to give assurances to the Client’s board that the Contractor was contributing towards their key strategic intentions. This meant that everyone was working towards the same result and mutual goals were seen to be the only way to make a partnership work. As the framework lasted for five years, long term commitment was not only reinforced but it also allowed for relationships to develop, which gave the parties the opportunity to assess the success of the framework under the 'bigger picture' perspective.

The five year programme also meant that a mutually acceptable resolution on each specific issue was possible. There was acknowledgement that neither party was trying to win at the other party's expense although the Client admitted that they used the lure of five years worth of work as buying power to drive costs down but defended this as good commercial practice, although stated that they do not deliberately set out to disadvantage the Contractor as there was no benefit in putting Contractors out of business. The Client regarded the prices, profits and benefits on offer to the Contractor as fair and, likewise, the Contractor stated that they are aware that the Client understands that Contractors have to make a profit. However, the Contractor had reservations over the mechanisms used at tender stage to establish pricing levels, particularly regarding what exactly was included in the price for a 'standard' item, which the Client seemed reluctant to clarify. The Contractor advised that some members of the Client's team may have tried to push the boundaries on certain projects but other individuals recognised the good, trusting relationship that had been long established and overall the Contractor felt that profits were fair as they had surpassed their own internal targets for the framework by 1%.

Contrary to the findings of Brookes (2008), both parties affirmed that mutual trust existed having been developed over the previous frameworks, and they advised that communication was effective. However the Contractor felt that it would have been better if verbal correspondence had been confirmed in writing. The Client admitted that they had not always listened as well as they could have done, although this was attributed to individual employees as opposed to an imposed approach. Generally, although open book accounting was required, trust and co-operation was evident and the contract was rarely referred to.

4.3 Time, Cost and Quality

In terms of time, cost and quality savings, both parties were of the opinion that partnering had contributed to cost savings, although this could not be substantiated. The Contractor attributed their savings to the bigger picture of future work becoming available and so it was possible to gear up for the efficient level of management required, thus reducing mobilisation and demobilisation. This contrasts with the findings of Emsley (2005) and Hirst (2009). In addition, the assured level of work enabled them to achieve economies of scale with plant and material suppliers, such savings also benefiting the Client who can subsequently be offered a lower price for each project. Time savings had been made in the sense that most projects finished within the contract period although the Contractor advised that the nature of the work undertaken in the framework did not assist in saving time as each project was unique, although there were also instances where the Contractor had to find time savings in the physical construction of the project in order to meet the deadline. Both parties agreed, however, that partnering achieves time savings due to there being a better understanding of processes, several overlapping activities and many parallel elements such as design, procurement and mobilisation. It was believed that working in the Framework improved quality as the Contractor was keen to be awarded future work. Other factors of significance included the 'quality' KPI incentive which is integrated into the pain gain mechanism; the nature of a long term relationship that enables a main Contractor to improve the quality over time; the focus on mutual goals and a high level strategic understanding of each other's organisations. Also, with the Framework consisting of a small number of Contractors all working on similar projects, there was the opportunity to share knowledge and best practice. This was demonstrated by all framework partners coming together to develop a 'defects avoidance booklet' that helped identify common areas where quality was a problem.

4.4 Partnering Relationship

In respect of the benefit of achieving a better general relationship, it is interesting that the Contractor was of the opinion that the relationship could have been better, whereas the Client was very happy. Having received relatively positive responses to the relationship characteristics (mutual trust, co-operation, win:win attitude etc) from the Contractor it seems peculiar that when asked outright about the general relationship they indicated a small level of dissatisfaction. Therefore it is difficult to obtain a wholly accurate depiction of the relationship with a number of interconnected characteristics occasionally contradicting one another. This aside, it was stated by both parties that the Framework overall was satisfactory.

In terms of the limitations of partnering, the Contractor advised that there were instances where both parties failed to adhere to the prominent partnering characteristics but, once again, the 'bigger picture' was underlined. The Client identified 'effective communication' as being one characteristic that had not always been adhered to - possibly because they came from the public sector at one time and it is inherent for them to be inflexible and that some individuals within the organisation did not fully understand the needs of the Contractor. The Client denied that they are indifferent but admitted that they can be inflexible, although they stated that through working closely in a partnering agreement, responsibilities and accountabilities can become blurred and, perhaps these should be formalised. There was a concern from the Contractor that when savings had to be made these always emanated from the asset creation programme and its supply chain and not other areas of the Client's business. The Client advised that an area of improvement on both sides would be to define the scope of work correctly at the outset in order for economic realities to have less significance, and for the fixed price to be seen as a fair reflection of the final delivered product at project completion. The Client admitted that the Contractor is seen as substitutable in the sense that there are a small number of 'non-core' Contractors who whilst not guaranteed work under the Framework, are allowed to tender for 'special projects' located outside of it. To this extent, the Contractor is conscious of the fact that a major slip in performance can result in a 'non-core' Contractor taking their place. However, the Client stated that this 'threat' is not over exploited and that commercial pressures, such as the recent recession, has not made them immediately compromise their partnering ethos.

5. Conclusion

Both parties deemed the partnership to have been a success and the findings of this paper demonstrate that partnering has worked in this particular case. Firstly, the findings illustrate that by embracing several prominent partnering characteristics the parties have established an effective and productive relationship which, in alignment with the partnering philosophy, is principally non-adversarial. Secondly, the majority of the reported benefits of partnering are evident, although some of these may not be exclusively attributed to partnering. This represents a level of success for all proponents of partnering, particularly Latham (1994) and Egan (1998).

With regard to the aims of this research paper, the partnering philosophy has had a positive effect with regard to the Client : main Contractor relationship whereby a partnership has formed between two separate and traditionally opposed entities who in the main have strived to co-operate and treat one another with trust and respect. This in turn allows both companies to prosper. In terms of project performance, partnering has attained cost savings, increased quality and improved health and safety, albeit that there are no figures to substantiate the claims. Project performance has been achieved through exploiting each party's resources and thus creating a synergy for construction success. The significance of this is that companies from all construction sectors should be encouraged to adopt partnering for better relationships and project outcomes.

Although, the findings have established that this relationship has fundamentally embraced the majority of the prominent partnering characteristics, they have also raised questions as to which characteristics are essential for success. For example, lack of a partnering charter meant that a formal conflict resolution process was not in place, contrary to the recommendations of Cheung et al. (2003. However, a good trusting relationship was in place despite Brookes (2008) assertion that this was not possible. The same can be said of risk; although not apparently explicitly shared, in line with the findings of Bennett and Jayes, (1998) and Black et al. (2000), there were effective mechanisms and financial provisions in place. Perhaps the most significant and fresh insight into partnering emanating from this research is the requirement for both the Client and main Contractor to assess partnering performance under the 'bigger picture' perspective. This outlook, which is reliant on long term commitment, appears to be the critical factor in allowing partnering to succeed within the water sector's frameworks. The 'bigger picture' perspective is a logical and relatively novel way of managing a business to business relationship within the construction industry.

The reported limitations, whilst being evident, did not adversely affect either the relationship or the project success. As has been established, where certain limitations have been apparent, these were either expected from the outset or accepted as the framework progressed under the 'bigger picture' perspective. In a simplistic summary, Latham (1994) and Egan (1998) primarily promoted partnering to end the adversarial relations that blighted the construction industry, promote long term relationships based on co-operation and increase profits for all. This research has ascertained that these aspirations were achieved in this case through the use of partnering. These two parties are not adversarial, they have a longstanding, successful relationship and the Contractor has exceeded their own target margin by over 1%, whilst the Client is making efficiencies in line with OFWAT's determinations.

The implications of this research indicate that partnering should continue to be adopted within both this sector and the construction industry as a whole. The way in which partnering is fostered is primarily dependent on the Client and does not have to explicitly adhere to the ethos of Latham

(1994) and Egan (1998). However, the Client must ensure that the way in which the partnering philosophy is interpreted and subsequently implemented must remain fair and equitable to all parties and embrace as many of the prominent partnering characteristics as possible.

Future research could focus on the relationships between other water companies and main Contractors. This will reaffirm whether this particular relationship is a one-off, or whether the water sector has adopted a partnering approach throughout and is profiting from the benefits. It would also be fruitful to undertake similar research between this water company and another main Contractor or this Contractor with a different water company to see if the findings are similar and whether the 'bigger picture' perspective can be transferred to other relationships. Although limited to one particular sector within the UK, the resuts of this study could be compared with similar relationships within different sectors of the industry, or even internationally, to determine whether parties act in the same manner regardless of who the partner is, or whether the behaviours and attitudes presented in this paper are limited to this relationship. Finally, the research focuses on the period 2005 – 2010 and a Framework which was relatively unaffected by the recent recession. It may have been helpful to have incorporated an angle that assessed how partnering is affected by a recession. This would have produced a truly up to date, live document from which managers and organisations could immediately utilise the findings and recommendations.

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Positive and Negative Factors Influencing the Implementation of Relational Contracting in Public Construction Projects in Australia

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Abstract

Despite relational contracting (RC) having been used increasingly in public funded construction projects in some countries such as Australia, there are different perspectives and concerns about RC. This research aims to understand the perceptions of what makes RC attractive or otherwise as a contracting strategy for public construction projects using Australia for data collection. Literature review was used to identify relevant factors, which were incorporated into the survey questionnaire. An online questionnaire survey technique was used for primary data collection from the greater Sydney region. The survey response data was subjected to descriptive statistical analysis using SPSS software. The research results show that RC is perceived as attractive in terms of positive factors including "Improve design", "Improve quality of project", "Build up closer relationship with contracting parties", "Reduce time in delivering the project" and "Enhance the organization's reputation in the industry". The most negative aspects and factors included "Public sector accountability concerns", "Lack of training and guidance in relational arrangement", "Stringent public rules, regulations and laws", "Conservative industry culture inhibits changes and encourages preservation of the status quo", and "Concerns about opportunistic behaviour of other contracting parties". These negative factors may make RC arrangement less attractive. As the delivery of public facilities and services is exhibiting more RC behavioural patterns, this research suggests that at the early stage of preparing a business case, a clear and common understanding of the positive and negative factors surrounding RC by the parties involved, would provide a more informed basis for decision making.

Keywords: Relational Contracting, Public Construction Project, Success Factors, Sydney

1. Introduction

Relationships between project team members include formal liaisons and relational links. Formal contracts set out the rights, responsibilities and liabilities of the parties. But in a formal contract, parties act in an atomized manner, looking out for their own personal interests (Williamson, 1975). Relational contracting (RC) is based on recognition of mutual benefits and win-win scenarios through more cooperative relationships among contracting parties, and underpins various approaches, such as partnering, alliance, joint venturing, long term contracting, joint risk sharing mechanisms and other collaborative working arrangements (Rahman and Kumaraswamy, 2004a). RC allows mutual future planning and considers contracts to be relationships among the parties, in the process of projecting exchange into the future (Macneil, 1974). While RC principles are less difficult to apply in private sector projects (Kumaraswamy, 2010), it is not known if public sector projects can enjoy the full benefits of RC like to reduce risks, reduce costs, and achieve better performance (Akintoye and Main, 2007). This is because public clients are not in a position to offer any future relationships, since most projects must be procured through competitive bidding process (Rahman and Kumaraswamy, 2004b). Yet, public projects are highly visible, and need to achieve the basic triple project goals (time, cost, quality) because tax payers' money is involved. It is therefore worth investigating the feasibility of RC in public construction projects.

In Australia, project alliancing would be considered for delivering complex and high-risk infrastructure projects, while in other cases the traditional approaches to procurement would be used (NSW Procurement, 2010). The history of collaboration with private sectors in Australia government could be tracked back to 1999, when "C1999-31 Guidelines for Collaboration and Integrated Services" was issued. In 2006, the Department of Treasury and Finance in Victoria issued another guide titled "Project Alliance Practitioners' Guide". It was then replaced by the latest issue of "Practitioners' Guide to Alliance Contracting (Exposure Draft)", which was prepared in July 2010 to provide consistent and leading practice guidance on alliance contracting to Western Australian, Queensland, NSW and Victorian Government departments and agencies that develop and own infrastructure projects. Although RC has been used increasingly in public funded construction projects in Australia, there are different perspectives and concerns towards RC (Clifton et al., 2004). The paper aims to understand the perceptions of what makes RC attractive or otherwise as a contracting strategy for public construction projects in Australia.

2. Literature Review

RC can benefit clients, contractors, consultants and on-site employees, which has been highlighted in recent research publications. From the literature review of works by Akintoye and Main (2007), Chan et al. (2003a), Black et al. (2000), Li et al. (2001), Lu and Yan (2007) and others, 21 positive factors of RC were identified. The abovementioned literature mainly focused on the perception of RC approaches in general construction project. The applicability of these in public construction projects in Australia was tested in the field work.

Different parties working together in a project are required to commit themselves and it is very difficult to change to cooperative and collaborative thinking especially for contracting parties in public construction projects (Eriksson et al., 2008). Reason responsible for unsuccessful collaboration in construction is also a hot research topic. The works of Eriksson et al. (2008), Glagola and Sheedy (2002), Kumaraswamy et al. (2005), Chan et al. (2003b), Ng et al. (2002) and others were reviewed. 23 negative factors of RC were identified and subsequently tested in the fieldwork of public construction projects in Australia.

3. Data Collection and Analysis

A questionnaire survey is a research instrument consisting of a series of questions for the purpose of gathering information from respondents, which is appropriate for this study to investigate the perception towards RC. A structured questionnaire survey was therefore conducted between June and November 2011 in Sydney. The objectives of the survey were to evaluate the extent to which collaborative practices were present, observed, practised or emphasized in projects; and to assess the driving and impeding factors for adopting RC/collaborative practices. Public sector officials, private architects, engineers, quantity surveyors, project managers and contractors (as well as subcontractors), who had been involved in public construction projects, were targeted. Respondents were requested to provide data of a completed public sector project that they had been involved in.

Since there is no national registry of officials/firms involved in public construction projects, the size of the population is not known. The sampling frame for public officials was obtained from government directories. As the number of people in this group was not likely to be overwhelming, questionnaires were sent to all identified public officials. The sampling frame for private consultants and contractors was derived from the respective professional and trade institutions. Random sampling was used to select the samples from these identified groups. As this group may contain those who have not handled public projects, the questionnaire clearly stated that only those who had completed public projects should fill up the questionnaire. In total, 322 sets of survey invitations were sent out, and 30 valid completed questionnaires were returned.

The questionnaire included six sections (i.e. Section A - Characteristics of the Public Project/Facility, Section B - Practices Present, Observed, Practiced, or Emphasized in the Specific Project identified in Part A, Section C - Motives/Drivers to Adopt RC Practices, Section D - Impeding Factors to Adopt RC Practices, Section E - Other Suggestions and Comments on Implementing RC Practices, and Section F - General Information). This paper focuses on the findings relating to motives /drivers to adopt RC practices and impeding factors to adopt RC practices. Respondents were requested to rate their degree of agreement with each of the identified factors according to a five-point Likert scale (1=Strongly disagree; 3=Neither; 5=Strongly agree).

The data were analyzed using SPSS software. Main statistical methods were one-way ANOVA (used to test the hypothesis that viewpoints from different groups of respondents are equal) and One-Sample T Test (to test the hypothesis that the positive/negative factors are equal to 3). The significance level was set at 0.05.

The content validity has been addressed during the questionnaire development stage by an in-depth literature review and a pilot-test of the questionnaire based on inputs from 9 industry practitioners before the dispatch of questionnaire. Cronbach's alpha reliability test was adopted to examine the internal reliability. The Cronbach's alpha values of section C and D were 0.891 and 0.966, which were greater than 0.7 and therefore are acceptable (Nunnally, 1978).

The characteristics of the respondents are given in Table 1. Most of the respondents have rich construction experience. The number of years of respondents' experience ranged from 2 to 45 years with an average of 24 years. 72.4% of the respondents had no less than 15 years of experience. The respondents' firms engaged between 3 and 100000 employees with an average of 7037 employees. Results showed that 67.9% of the respondents' firms had greater than 200 employees.

Table 1: Background of respondents

Background		*Number*	*Percentage*
Number of years practiced in the construction industry	*< 5 years*	*6*	*20.7%*
	5-9 years	*1*	*3.4%*
	10-14 years	*1*	*3.4%*
	≥ 15 years	*21*	*72.4%*
	Average	*24*	
	Min	*2*	
	Max	*45*	
Organization type	*Government*	*9*	*31.0%*
	Engineering firm	*2*	*6.9%*
	Architectural firm	*1*	*3.4%*
	Quantity surveying firm	*1*	*3.4%*
	Contractor	*16*	*55.2%*
	Others	*0*	*0.0%*
Ownership of organization	*Public*	*16*	*55.2%*
	Private	*13*	*44.8%*
	Joint Venture	*0*	*0.0%*
Size of total workforce	*1-20 employees*	*2*	*7.1%*
	21-200 employees	*7*	*25.0%*
	> 200 employees	*19*	*67.9%*
	Average	*7037*	
	Min	*3*	
	Max	*100000*	

4. Results and Discussion

4.1 Positive Factors

An ANOVA analysis was conducted to evaluate the differences of the scores of positive factor among different contracting parties (i.e. clients, contractors and consultants). The results were shown in Table 2. There were no significant difference among the perspectives of clients, contractors and consultants, as all the significance values were greater than 0.05. A high extent of agreement was therefore valid among the three sets of ratings, to allow lumping the three sets of data together for the obvious reason of having a larger sample size. However, this may be due more to the limited number of respondents in this study than to the absence of differences among views from contracting parties. Marginal differences were observed in the “Respond to technology changes” ($p = 0.137$) and “Seize new market opportunities” ($p = 0.152$). The mean rating values for contractors (3.75) and consultants (3.91) on “Respond to technology changes” are higher than those of client respondents (2.80). Since design and construction are the responsibility of the contractors and consultants, it is important for that party to actively seek ways of increasing productivity and responding to technology changes. “Seize new market opportunities” is considered more important attraction by the contractors (3.83) than by the clients (2.80) and consultants (3.18).

Insert Table 2 here.

The means for positive factors were calculated as shown in Table 2. The mean values for the positive factors ranged from 3.36 to 4.41. This observation has reflected a high degree of agreement on the positive factors from the respondents. According to the One-Sample T Test against 3, 19 out of 21 positive factors were significantly greater than 3, as their significance values were less than 0.05. This again reinforces that RC principles are of great benefit to public construction projects. Table 2 shows that the significant positive factors rated highest by respondents could be categorised into two categories, i.e. improvement of project performance and self-improvement.

Positive factors to improve project performance include “Improve the design” (1st), “Improve the quality of project” (2nd), “Reduce time in delivering the project” (4th), “Reduce disputes during the project” (6th), “Reduce risks and/or mitigate their influence” (7th) and “Achieve better safety performance” (8th). Performance improvement is the primary objective in the introduction of RC principles in public construction projects. Clearly, this result could therefore have been anticipated.

The other main category of positive factor is self-improvement, including “Build up closer relationship with contracting parties” (3rd), “Enhance your organization’s reputation in the industry” (5th) and “Improve your organization’s competency” (9th). The attractiveness of RC in self-improvement is recognised by the respondents. It appears that respondents are aware of the need for their organizations to demonstrate continuous improvement in order to get more work in future.

4.2 Negative Factors

An ANOVA analysis was conducted to evaluate the differences of the scores of negative factor among different contracting parties (i.e. clients, contractors and consultants). The results were shown in Table 3. There were no significant difference among the perspectives of clients, contractors and consultants, as all the significance values were greater than 0.05. A high extent of agreement was therefore valid among the three sets of ratings, to allow lumping the three sets of data together for the obvious reason of having a larger sample size.

Insert Table 3 here.

Table 3 presents the means of negative factors calculated. The mean values ranged from 2.23 to 3.42. This observation has reflected a low degree of agreement on the negative factors from the respondents. According to the One-Sample T Test against 3, only 1 out of 23 negative factors was significantly greater than 3; while 2 negative factors were significantly less than 3. One explanation may be the survey limitation of natural inclination on negative factors of respondents to avoid extremes of subjective opinion rather than the absence of any extremely important factors. Yet, to some extent, these could still reinforce the high possibility to apply RC practices in public construction projects, as negative factors are not recognised as significantly important.

The only negative factor significantly greater than 3 was "Public sector accountability concerns" (3.42). It is worth noting that the mean value from clients for this negative factor was 4.00. The implication is that concerns of public sector accountability should be considered in order to pave the way to implementation of RC in public construction projects. The two negative factors significantly less than 3 are "Lack of top management support (each party)" and "Unenthusiastic participation of contracting parties". These may be because contracting parties think they have presented great support and participation of RC practices. Another explanation is that respondents may overestimate their participation and performance in the projects.

The top negative factors comprised "Public sector accountability concerns" (1^{st}), "Lack of training and guidance in the relational arrangement" (2^{nd}), "Stringent public rules, regulations and laws" (3^{rd}), "Conservative industry culture inhibits changes and encourages preservation of the status quo" (4^{th}) and "Concerns about opportunistic behavior of other contracting parties" (5^{th}). It is obvious that all the top negative factors were related to macro public environment and culture. It therefore greatly relies on the efforts from the government and may take a long time to overcome the macro level of barriers. For example, given that construction is a project-based industry where time and scope are seen in a narrow perspective, it may take a long time before cooperative relationships result in continual improvement and increased profitability (Ingirige and Sexton, 2006).

Other negative factors no less than 3 included "Lack of knowledge of relational approaches" (6^{th}), "Lack of experience of relational arrangement" (7^{th}) and "Time required to develop relationship" (8^{th}). These were considered as organizational level of barriers. This is consistent with Eriksson et al. (2008) in Swedish construction industry which identified three types of negative factors to RC: i.e. cultural, organizational and industrial barriers.

5. Conclusions

The relative importance of 21 RC positive attractiveness factors was investigated through a survey conducted in Sydney. The results show that projects adopting RC principles exhibit positive attractiveness because of their possible ability to improve project performance as well as their organizations. However, RC concept is not totally accepted in all public construction projects. Among the 23 potentially negative factors, which might cause potential participants to reconsider their involvement, the factors with a mean value no less than 3 could be categorized into macro and organizational levels of barriers. The observation of high agreement on positive factors and low agreement on negative factors may indicate the great potential to apply RC principles in public construction projects.

It is recommended that these factors, representing the positive and negative characteristics exhibited in RC procurement, should be considered by public sector clients, and by potential private sector business case developers.

6. Acknowledgements

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Table 2: Statistical results of positive factors

No.	*Positive Factors*	*Mean*	*T*	*Sig.*	*Rank*	*Client*	*Contractor*	*Consultant*	*F Value*	*Sig.*
C-1	*Reduce total project cost*	*3.96*	*6.854*	*0.000**	*11*	*4.00*	*3.92*	*4.00*	*0.040*	*0.961*
C-2	*Reduce risks and/or mitigate their influence*	*4.14*	*8.000*	*0.000**	*7*	*4.00*	*4.25*	*4.09*	*0.222*	*0.802*
C-3	*Reduce the cost of changing partner in projects*	*3.50*	*2.201*	*0.036**	*18*	*4.00*	*3.67*	*3.09*	*1.203*	*0.317*
C-4	*Reduce time in delivering the project*	*4.21*	*7.718*	*0.000**	*4*	*4.20*	*4.17*	*4.27*	*0.044*	*0.957*
C-5	*Reduce public client's administration burden*	*3.54*	*3.382*	*0.002**	*17*	*3.80*	*3.67*	*3.27*	*0.932*	*0.407*
C-6	*Provide an integrated solution of efficiency improvement*	*3.89*	*6.408*	*0.000**	*14*	*4.00*	*3.75*	*4.00*	*0.376*	*0.690*
C-7	*Improve the quality of project*	*4.32*	*9.674*	*0.000**	*2*	*4.20*	*4.08*	*4.64*	*1.881*	*0.173*
C-8	*Improve the design*	*4.41*	*11.498*	*0.000**	*1*	*4.20*	*4.36*	*4.55*	*0.531*	*0.595*
C-9	*Respond to technology changes*	*3.64*	*3.204*	*0.003**	*16*	*2.80*	*3.75*	*3.91*	*2.152*	*0.137*
C-10	*Achieve better safety performance*	*4.14*	*8.000*	*0.000**	*8*	*4.20*	*4.17*	*4.09*	*0.043*	*0.958*
C-11	*Facilitate creative and innovative approaches*	*3.96*	*6.437*	*0.000**	*12*	*4.00*	*3.83*	*4.09*	*0.293*	*0.749*
C-12	*Enhance your organization's reputation in the industry*	*4.18*	*6.600*	*0.000**	*5*	*4.20*	*4.17*	*4.18*	*0.002*	*0.998*
C-13	*Improve your organization's competency*	*4.11*	*6.392*	*0.000**	*9*	*3.80*	*4.00*	*4.36*	*0.781*	*0.469*
C-14	*Reduce disputes during the project*	*4.18*	*10.193*	*0.000**	*6*	*4.00*	*4.17*	*4.27*	*0.328*	*0.723*
C-15	*Build up closer relationship with contracting parties*	*4.25*	*9.442*	*0.000**	*3*	*3.80*	*4.33*	*4.36*	*1.288*	*0.293*

No.	Positive Factors	Mean	T	Sig.	Rank	Client	Contractor	Consultant	F Value	Sig.
C-16	Maximize resource utilization	4.04	6.914	0.000*	10	4.20	4.08	3.91	0.255	0.777
C-17	Respond to collaborative culture in the project	3.96	6.437	0.000*	13	3.60	4.00	4.09	0.664	0.524
C-18	Seize new market opportunities (eg. pursuing future relationships)	3.39	1.890	0.070	20	2.80	3.83	3.18	2.035	0.152
C-19	Achieve continuity with prior developments	3.50	2.750	0.011*	19	3.00	3.83	3.36	1.569	0.228
C-20	Respond to competitors' actions (enhance competitive position)	3.36	1.842	0.077	21	3.00	3.67	3.18	1.010	0.379
C-21	Respond to public/social/end-users' needs	3.68	3.968	0.000*	15	3.80	3.67	3.64	0.054	0.948

Table 3: Statistical results of negative factors

No.	*Negative Factors*	*Mean*	*T*	*Sig.*	*Rank*	*Client*	*Contractor*	*Consultant*	*F Value*	*Sig.*
D-1	*Lack of knowledge of relational approaches*	*3.04*	*0.176*	*0.862*	*6*	*3.00*	*3.20*	*2.91*	*0.171*	*0.844*
D-2	*Public sector accountability concerns*	*3.42*	*2.101*	*0.046**	*1*	*4.00*	*3.30*	*3.27*	*0.978*	*0.391*
D-3	*Lack of training and guidance in the relational arrangement*	*3.31*	*1.443*	*0.161*	*2*	*3.80*	*3.30*	*3.09*	*0.715*	*0.500*
D-4	*Lack of trust among all contracting parties*	*2.77*	*-0.881*	*0.387*	*12*	*2.80*	*2.90*	*2.64*	*0.096*	*0.909*
D-5	*Past negative experience of relational arrangement*	*2.73*	*-1.193*	*0.244*	*15*	*2.40*	*2.80*	*2.82*	*0.241*	*0.788*
D-6	*Lack of experience of relational arrangement*	*3.00*	*0.000*	*1.000*	*7*	*3.20*	*2.90*	*3.00*	*0.092*	*0.913*
D-7	*Misgiving about potential future relationships*	*2.77*	*-1.063*	*0.298*	*13*	*2.80*	*2.90*	*2.64*	*0.141*	*0.870*
D-8	*Lack of empowerment in the client's representatives*	*2.69*	*-1.248*	*0.224*	*18*	*2.80*	*3.00*	*2.36*	*0.675*	*0.519*
D-9	*Unenthusiastic participation of contracting parties*	*2.23*	*-3.801*	*0.001**	*23*	*2.00*	*2.50*	*2.09*	*0.546*	*0.587*
D-10	*Lack of top management support (each party)*	*2.38*	*-2.476*	*0.020**	*22*	*2.20*	*2.50*	*2.36*	*0.089*	*0.915*
D-11	*Lack of client’s initiatives in RC practice*	*2.73*	*-1.158*	*0.258*	*16*	*2.40*	*3.00*	*2.64*	*0.467*	*0.633*
D-12	*Bureaucratic public client organization*	*2.96*	*-0.171*	*0.866*	*9*	*2.60*	*3.10*	*3.00*	*0.309*	*0.737*
D-13	*Lack of common goals among*	*2.50*	*-1.830*	*0.079*	*21*	*2.60*	*2.60*	*2.36*	*0.085*	*0.919*

No.	Negative Factors	Mean	T	Sig.	Rank	Client	Contractor	Consultant	F Value	Sig.
	contracting parties									
D-14	Stringent public rules, regulations and laws	3.08	0.328	0.746	3	2.60	3.10	3.27	0.525	0.599
D-15	Lack of acceptance by contracting parties of relational approaches as a long-term way of doing business	2.77	-1.140	0.265	14	2.60	3.10	2.55	0.828	0.449
D-16	Inter-personal/cultural clash (individual level)	2.73	-1.070	0.295	17	2.40	2.70	2.91	0.259	0.774
D-17	Need to avoid possible allegations of corruption arising from close relationships between client and other contracting parties	2.85	-0.582	0.566	11	2.40	2.80	3.09	0.441	0.649
D-18	Conservative industry culture inhibits changes and encourages preservation of the status quo	3.08	0.348	0.731	4	3.00	3.30	2.91	0.310	0.736
D-19	Concerns about opportunistic behavior of other contracting parties	3.08	0.359	0.723	5	3.00	3.00	3.18	0.081	0.922
D-20	Incompatible organizational cultures in the contracting parties	2.69	-1.355	0.188	19	2.80	2.50	2.82	0.210	0.812
D-21	High cost to adopt relational approaches	2.69	-1.316	0.200	20	2.60	2.70	2.73	0.018	0.982
D-22	Time required to develop relationship	3.00	0.000	1.000	8	3.40	2.90	2.91	0.265	0.770
D-23	Client only has occasional need for project development	2.88	-0.486	0.631	10	3.00	3.20	2.55	0.779	0.470

The Principal-Agent Theory and the Role of Project Managers in Construction: Guidelines for Future Research

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Abstract

The principal-agent theory has been successfully applied to the research of management of construction projects. It has focused on the relationship between the project owner as principal and the contractor as agent. Also, the relationship between the contractor as principal and sub-contractors as agents has been explored. After introducing the literature in this field, this paper will present recent research into the relationship between the project owner's and contractor's project managers along the lines of the principal-agent theory. An exploratory survey was used at the first stage of research. After the exploratory survey, the Delphi method was employed for further exploration of the issues involved. It has been shown that the two managers play key roles in the construction phase even though they are both agents not related by contracts. Risk minimization is their main concern in the construction phase. Having summarized this research, the paper addresses the opportunities for further research in this area, which offers a challenge to the principal-agent theory in the field of construction. Guidelines for future research take the central part of the paper. They focus on communication risks caused by asymmetric information, which are of central importance to the principal-agent theory.

Keywords: principal-agent theory, asymmetric information, communication risk, risk minimization, project management

1. Introduction

Good communication between key participants is most important for the success of every construction project. Communication involves sharing relevant information between project participants. Poor communication has been shown to be one of the most common project risks (Ceric, 2003). It is usually assumed that all participants cooperate and exchange information in order to achieve project's goals. Actually, there is a potential conflict of interests between project participants because they all have their own interests, as well.

The situation in which one of the two parties is better informed than the other is recognized in economics as the *principal-agent problem* (*e.g.*, Jäger, 2008). In construction projects, the project owner and contractor as principal and agent form the key relationship (Turner and Müller, 2004). Delegation of tasks establishes a principal-agent relationship between the project owner and manager, where the principal (project owner) depends on the agent (contractor or project manager) to undertake a task on the principal's behalf (Müller and Turner, 2005). It can be assumed that an agent will try to maximize his or her own benefit even when that may involve a higher damage to the client (Schieg, 2008). According to the principal-agent theory, this problem is characterized by three issues concerning the relationship between the principal and the agent: adverse selection, moral hazard, and hold-up. These three issues will be discussed in the following section.

The literature review shows that the application of the principal-agent theory in construction is extensive. It covers all three issues of risk concerning the relationship between the principal and agent: adverse selection, moral hazard, and hold-up. Analyzing papers that have been published so far, it can be concluded that most authors have researched moral hazard dealing with supply chain management, procurement systems, make-or-buy decisions, and outsourcing (Rosenfeld and Geltner, 1991; Tedelis, 2002; Yiu *et al*., 2002; Ive and Chang, 2007). Several authors have discussed the adverse selection problem and its impact on building performance and building quality (Holt *et al*., 1995; Corvellec and Macheridis, 2010). It should be noted that the hold-up problem dealing with sub-contracting and procurement systems has attracted least attention so far (Chang and Ive, 2007; Unsal and Taylor, 2010). A more detailed analysis of the key construction literature covering all three issues can be found in Ceric (2010). However, the literature does not cover the relationship between project managers in construction projects, which is central to the research outlined in this paper.

In the pages that follow, the principal-agent theory in construction is introduced first. A short summary of previous research conducted by the author is presented next (Ceric 2010; 2011). The paper closes with guidelines for future research regarding the application of the principal-agent theory to construction projects.

2. Principal-Agent Theory and Information Asymmetries in Construction Projects

The owner of a project is the person or group that provides the financial resources for its delivery, accepts the project milestones, and project completion (Project Management Institute, 2000). In a standard situation, the project owner hires a contractor to perform all the activities required to complete the project. According to the principal-agent theory, the relationship between the two parties also involves self interest of each party, which is also shown in Figure 1.

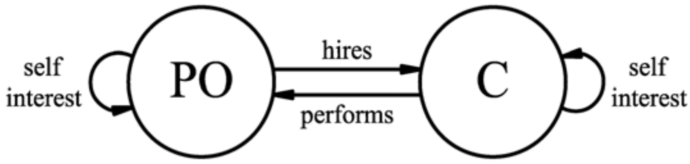

Figure 1: Project Owner - Contractor relationship (PO: Project Owner C: Contractor)

Also, the project owner and the contractor delegate their tasks to their project managers. Therefore, there are four different parties involved in the project even before its execution starts. It should be noted that the contractor's project manager is understood here as the person who is in overall charge of a particular project on contractor's behalf irrespective of the title. Namely, in some business environments this role is played by consultants. It is commonly assumed that all participants in the project will work together in order to achieve the same goal. However, there is a potential conflict of interests between the participants because they all have their self interests, too. Extending Figure 1, the relationships between all the above-mentioned participants taken together are shown in Figure 2. These are the key parties to any construction project.

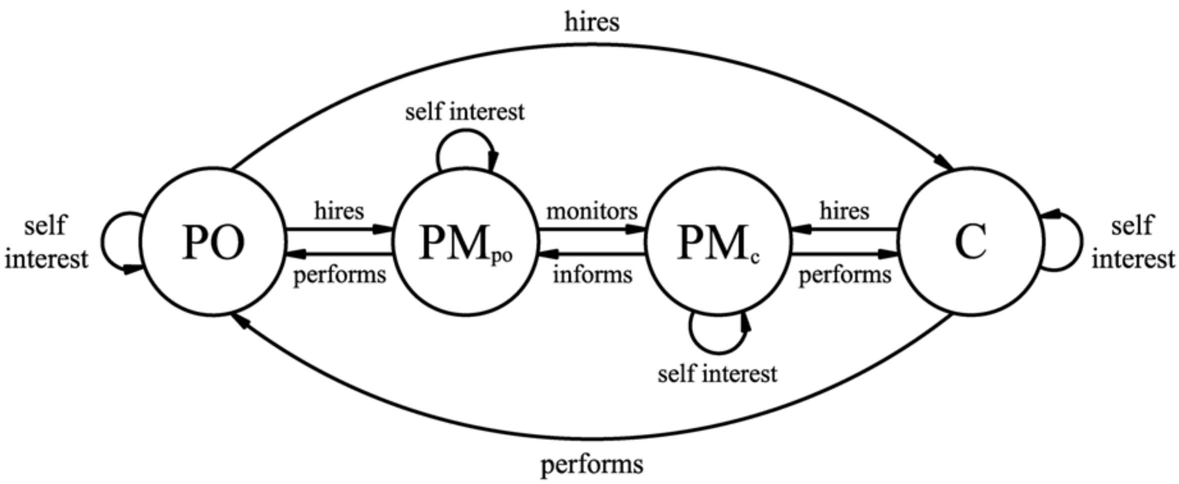

Figure 2: Principal-agent theory framework for construction projects (PO: Project owner, C: Contractor, PM_{po}: Project owner's project manager, PM_c: Contractor's project manager)

As it is shown in Figure 2, the project owner acts as the principal in relation to both the project owner's project manager and contractor as agents, and the contractor acts as the principal in relation to the contractor's project manager. Therefore, there are two principals and three agents involved, where the contractor is both a principal and agent in a project.

The situation in which one of the two cooperation partners is better informed than the other is characterized by *asymmetric information* (Schieg, 2008). After Akerlof (1970), much has been written on this subject. In 2001, George Akerlof, Michael Spence, and Joseph Stiglitz shared a Nobel prize in economics for this important work. Information asymmetries apply whenever the principal and the agent are not in possession of the same information at the same time. In construction projects, we have four key parties that work together, and it is assumed that they will share important information in order to meet main project's targets: time, cost, and quality. However, because of self interest, they will not be willing to share all the information all of the time. Therefore, the following types of information asymmetries apply for acting parties: *hidden characteristics*, *hidden information*, and *hidden intention.* Respectively, these three types of information asymmetries generate following risks: *adverse selection, moral hazard*, and *hold-up*.

Based on the principal-agent theory, relationships between the project owner and contractor, as well as the two project managers employed by them, are systemized according to related asymmetric information and corresponding types of risk. Hidden characteristics are associated with adverse selection; hidden action and/or hidden information are associated with moral hazard; and hidden intentions are associated with hold-up (*e.g.*, Jäger, 2008). Hidden characteristics cause the adverse selection problem *before* the contract is signed between the parties involved. It means that the project owner does not have all the information about the contractor before the contractor is hired. Similarly, the project owner does not have all the information about the project manager before hiring. The same holds for the contractor and the project manager working on the contractor's behalf. Therefore, in the case of adverse selection we have three different parties involved and three information asymmetries. The adverse selection problem occurs in the early phases of the project

Hidden information or hidden action causes the moral hazard risk. This occurs *after* the contract is signed between involved parties. For instance, the client cannot be sure that firms, once hired, will fully mobilize their capabilities on the client's behalf or on behalf of other clients of theirs (Winch, 2010). In our case, four parties are potentially involved in the moral hazard problem. After the relevant contracts are signed and the project owner has hired the contractor and the project manager, and after the contractor has hired the project manager, they cannot be sure that all information will be shared in an appropriate way because of the self interest of all the parties involved. The moral hazard problem also occurs between two project managers because they have their self interest, as well.

Hidden intentions can cause hold-up problems. The project owner can invest some money at any stage of the project and trust that the contractor will cooperate, but it can happen that the contractor will actually behave opportunistically. After the project owner realizes that the contractor is acting opportunistically, it can be too late for the project owner to withdraw investment. The same holds in the opposite direction. The contractor can also invest some money at any stage of the project and trust that the project owner will cooperate, but it can happen that the project owner will act opportunistically.

There are several ways to minimize risks that arise from adverse selection, moral hazard, and hold-up problems. These are known as *screening* and *monitoring* (Jäger, 2008; Schieg, 2008). As both screening and monitoring represent costs, they are known in the literature as "agency costs." The purpose of screening is to gather information of use to the principal in an effort to learn more about the agent's qualifications—for example, references, certificates, work probes, and credit worthiness. Similarly, the purpose of monitoring the agents is to ascertain that they are behaving in accordance with the contract. In other words, it helps reduce moral hazard and hold-up risks.

3. Exploratory Survey and the Delphi Method

Due to space limitations, this section provides a short summary of previous research conducted by the author concerning the principal-agent problem (Ceric, 2010; 2011). The research process consisted of two phases. First, the exploratory survey was conducted. The respondents were project managers with an appreciable experience in the filed. The average value of the largest project they managed was US$1 billion and they had fifteen years of experience on the average, working in a wide range of countries around the globe. Among more than thirty countries, they worked in Egypt, Hong Kong, India, Iraq, Italy, Pakistan, Poland, Russia, Saudi Arabia, Spain, Switzerland, Turkey, the United Kingdom, and the United States. A total of 27 project managers participated in the survey. Following the principal-agent theory, there were five questions. The first three concerned three issues of information asymmetry (adverse selection, moral hazard, and hold-up), which correspond to their three sources (hidden characteristics, hidden information, and hidden intentions), while the last two concerned two types of communication risk minimization (screening and monitoring). The respondents were asked to rate the importance of each issue addressed in five questions in terms of the four relationships between the key project parties, as shown in Figure 2.

The key finding from this exploratory survey was that, *after* the contract is signed between the project owner and contractor, the most important relationship in risk minimization is that between the project owner's and contractor's project managers. They are both agents and there is no contract between them, which is an interesting challenge for the principal-agent theory. Interestingly, a number of project managers suggested that communication protocols should be part of project administration so as to ensure better communication between all the participants.

Following the exploratory survey, there were two additional Delphi rounds. The results of the exploratory survey itself were considered as the first round. The Delphi method was chosen as an appropriate tool because the project managers are geographically spread apart. Also, they were not available for consultation over lengthy periods of time. All of the project managers that were selected from the exploratory survey for the next two Delphi rounds were practitioners with considerable expertise in the project management field, as witnessed by their thirteen years of experience on the average, and the average of the largest project they managed assessed at $1.4 billion. For the second Delphi round 20 of the 27 respondents were selected. In the final Delphi round, 11 out of 15 respondents took part. The focus was on risk minimization in the construction phase.

The key finding from the Delphi method confirmed and strengthened the main finding from the previous exploratory research. The central relationship in construction projects *after* the contract is signed is that between the project managers. Therefore, they play the most important role in the risk minimization process in the construction phase of a project.

4. Guidelines for future research

Taking into consideration the findings from the previous section, there are three directions for future research proposed here. First, strategies of communication risk minimization could be explored in further detail. Second, future research could look into more complex relationships between project participants. Third, the communication process between project participants could be investigated in much greater detail, so as to arrive at viable communication protocols. These possibilities will be briefly discussed below.

4.1. Selection of strategies for minimizing communication risk caused by information asymmetries

As argued in the previous section, the project mangers play the most important role in risk minimization in the construction phase *after* the contract between the project owner and contractor is signed. One of the possibilities for future research is focusing on the construction phase and selection of the appropriate strategies for minimizing communication risk between project participants caused by information asymmetries.

According to Schieg (2008), there are six strategies for minimizing information asymmetries between project participants:

1. bureaucratic control (contracts),
2. information systems,
3. incentives (bonuses),
4. corporate culture,
5. reputation, and
6. trust.

A survey could be used to establish the rank list of the six strategies mentioned above for risk minimization. Once again, the respondents would be project managers with considerable experience and expertise in the field. They would be asked to rate the importance of each strategy for minimizing information asymmetries mentioned above in terms of the four relationships between the key project parties: project owner-contractor; project owner's project manager-project owner; contractor-contractor's project manager; and contractor's project manager-project owner's project manager. After this step, the multi-attribute utility theory can be used for compiling a rank list of the strategies for risk minimization, calculating the overall utility function for each alternative.

4.2. Exploring more complex relationships between project participants

Future research should also consider more complex relationships between construction project participants, and especially the agents. In particular, this would involve consultants, such as designers—either engineers or architects. The relationships shown in Figure 2 could be widened by adding the designer to better understand the complexities of the construction process beyond the four key participants investigated heretofore (Figure 3).

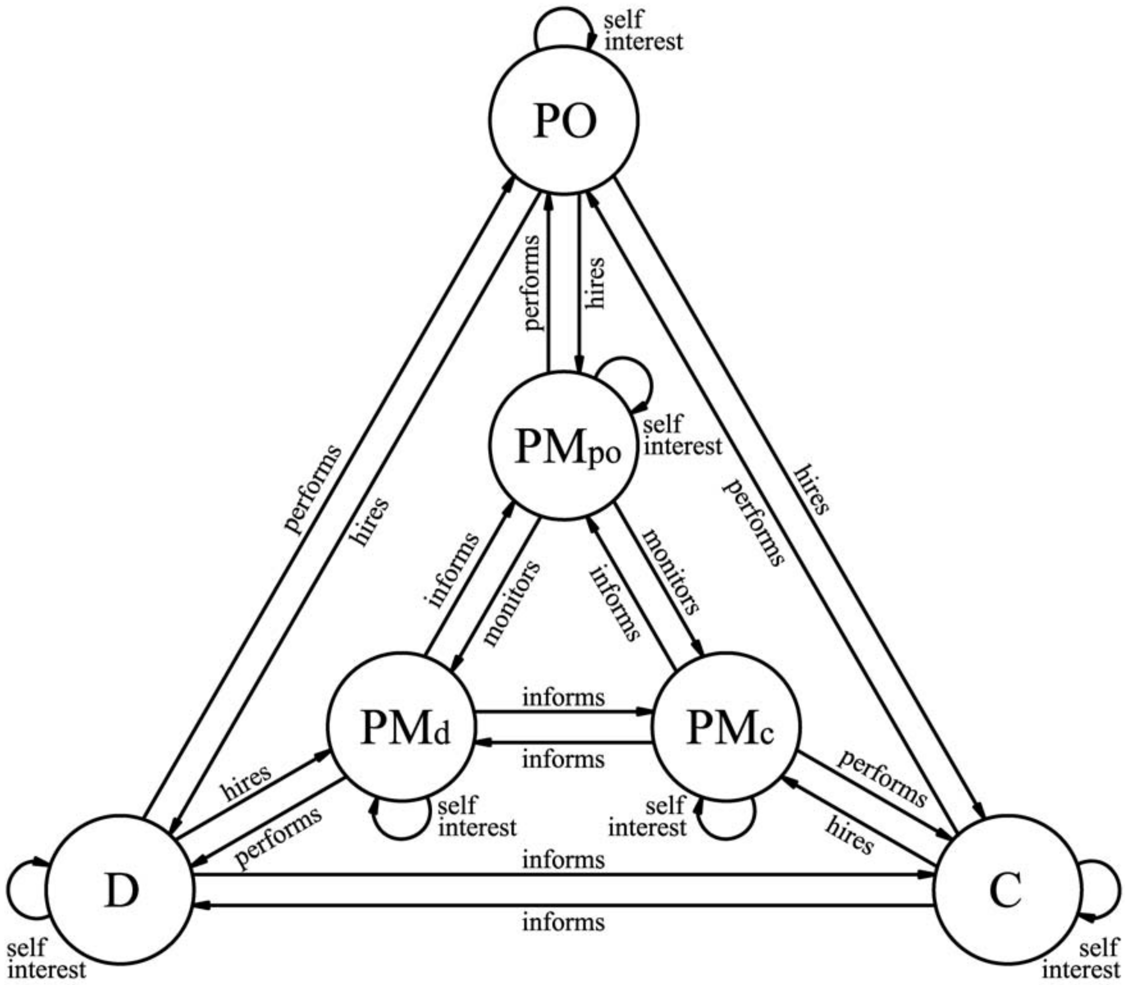

Figure 3: Principal-agent theory framework for construction projects (PO: Project owner, C: Contractor, D: Designer, PM_{po}: Project owner's project manager, PM_d: Designer's project manager, PM_c: Contractor's project manager)

As can be seen by comparing Figures 2 and 3, the number of relationships between the key project participants rapidly increases. When there are only the project owner and contractor, as well as their project managers, there are twelve relationships between them altogether, two of which are between project managers, who are not related by contracts. By comparison, there are twenty-four relationships when the designer and the designer's project manager are added. In addition, eight of these relationships do not involve contracts, which is a full third of all the relationships involved. Adding more project participants, such as sub-contractors, would furthermore complicate the picture quite rapidly.

4.3. Establishing communication protocols in contracts

Many of the communication problems occur in the construction phase, when conflict can become dysfunctional and disruptive (Emmitt and Gorse, 2007). Such conflict is detrimental to both the project owner and contractor as the principal and agent. Exploring the intricacies of the monitoring process would require much more detailed investigation of project managers and their interaction to arrive at the most promising interplay between formal and informal communication during construction. As shown by the exploratory survey presented in the previous section, communication protocols defined in contracts may help improve the monitoring process (Ceric, 2010). In particular, this is what a large number of respondents suggested in their comments to the survey. Such an investigation could be best achieved by means of interviews and/or focus groups.

4. Conclusions

As outlined in the Introduction, the principal-agent theory in construction was first introduced in this paper. Due to space limitations, a short summary of previous research conducted by the author was presented next. Guidelines for future research regarding the application of the principal-agent theory to construction projects complete the paper.

As has been argued in the previous section, there are three directions for future research worth considering at this stage. First, strategies of communication risk minimization could be explored. Second, future research could look into more complex relationships between project participants, including the designer. Third, the communication process between project participants could be investigated in greater detail, so as to explore viable communication protocols between the key project participants.

On the basis of research into the relationship between the project owner's and contractor's project managers conducted to date, it deserves greater emphasis in further research. Especially in the construction phase, this relationship is crucial for the understanding of project management as a field. The three directions outlined in the previous section offer great promise. Only by understanding better the relationships not regulated by contracts can we expect significant advance of the field.

5. Acknowledgments

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Phase Transition – Break Down the Walls

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Abstract

The integration of phases in the construction process is an issue not paid much attention. Recently research shown that inter-phase periods are a time when value for the project easily can decrease. Several reasons for this exists, among others contractual agreements, change in persons, etc. In a popular term this problem is often called "over the wall syndrome". The manufacturing industry has worked with this for many years, in e.g. integrated product development, concurrent engineering, supply chain management, etc. Now the construction industry needs to focus more on these crucial inter-phase issues of the construction process.

This research first identifies the problems theoretically, and looks into which framework to be used in understanding of the phase transition problem. This combined with data from interviews reveal 8 major issues in phase transition, which decrease the value of the project. Among others, lack of communication, too little involvement from the client, scare resources, and conflicting interest.

Special emphasis is put on analyzing the transfer of knowledge from design to construction. There is evidence that this is especially critically, since communication through tender often is limited due to regulations. Therefore, contractors miss a large amount of non-operational information, and the client and his consulting engineers never mange to share their tacit knowledge of project preconditions.

Keywords: Phase transition, value, construction process, cooperation

1. Introduction

The construction industry has long been known for its conservatism and for being traditional to a degree that has caused the industry to fall behind other industries in terms of innovation and productivity increase (Wandahl et al., 2011). The rate of innovation lags behind most other sectors, and appears to be falling further and further behind. Moreover, development efforts in the industry are disproportionately orientated towards product enhancement rather than process improvement (Winch 1998).

A construction process is divided into different phases. Often these phases are viewed as sequential, i.e. fragmented. Critique of this process is not new, but still very present. In e.g. Concurrent Engineering in Construction (Anumba, 2007), the idea is to integrate the different phases inspired by the manufacturing industry's thinking of Integrated Product Development. The main idea is to improve communication and apply a whole life cycle process mindset. This should keep "over the wall" issues away. In the fragmented process a phase transition often results in a value lose, which can have costly consequences for the final construction. Atkins et al. (2003) investigates which problems occurs as a direct consequence of the fragmented construction process. It is pointed out that each decision is a compromise between different participants with conflicting views on process and product. This calls for a defragmentation of the construction process where coordination and communication is in focus.

Several initiatives have been launched to improve the performance and image of the construction industry, such as e.g. Partnering, Digital Construction, Re-valuing construction, etc. (Bejder et al., 2008). These initiatives have each created significant value for individual companies, but none has successful focused on addressing the fundamental problem of defragmentation and value creation of the building process as a whole. Such approach will indeed have to directly address the distinct contextual characteristics of the construction industry.

This research aims at investigating the extent of problems due to phase transition. In this research only negative effects, e.g. value lose in the interfaces, not possible positive synergies are examined. Focus is, moreover, only on the interface between design and construction. This phase transition is selected, because the change from designers and consulting engineers to contractors is well-known for creating problem.

This leads to research question of this research:

What is the root causes to value lose in the phase transition between design and construction?

Initially some theoretical unravelling needs to be carried out.

1.1 Definition of phase transition

Worldwide different terminology and level of details is applied when defining the different stages of construction. Examples of different terminology:

- Conceptual design – Final design – Bid period – Construction period – Inspection and acceptance (Halpin & Senior, 2011)
- Pre-concept – Concept – Design – Construction – Handover (Kelly et al., 2002)
- Concept – Design – Tendering – Construction – Use (Naldal, 2006)

Several other examples could be put forward. What differs is in general whether or not tendering is seen as a phase, or as connector between two phases. Also it differs whether or not use is shown as a phase in connection to construction project management or as a Facilities Management discipline.

This research applies the following terminology, which could be seen as a synthesis of the above mentioned, cf. table 1.

Table 1: Phase overview.

	Concept	***Design***	***Construction***	***Use***
Purpose	*Client requirements, ideas, desires and needs*	*Complete design, ready for production*	*Construction of the physical product*	*Facilities Management*
Participants	*Client, client advisors and users*	*Architects and consulting engineers*	*Contractors, sub-contractors, suppliers and supervisions*	*Client and users*
Activities	*Pre-concept and concept*	*Design proposals and final design*	*Construction management*	*Facilities Management*
Outcome	*The clients brief*	*Final design*	*Finished construction*	*Manageable assets*

It is acknowledged that alterations of table 1 occur. Tendering is in this research viewed as a connector between two phases. In early tendering, i.e. Design-Build, tendering connects the concept and design phase. If late tender, i.e. Design-Bid-Build, tendering connects the design and construction phase.

As the phases now are defined, phase transition can be defined. A shift in phase is not completed within a single day. Instead it is a process, which more or less efficient creates an overlap or integration of two phases. In this overlap some actions and communication between project partners take place, but almost no Project Management literature treat this inter-phase period. As it is hard to find any Body-Of-Knowledge. This research defines a phase transitions as:

- A shift in purpose occurs.
- A change in active project participants.
- New subproject activities and purposes begin.

1.2 Theory framing the phase transition

No theory of phase transition in the construction process is easily found in literature. However, several related theoretical aspects are framing the problem.

In general it is recognised that the later one is in a construction project life cycle the less one can influence project costs. Wandahl (2004) illustrates this on figure 1.

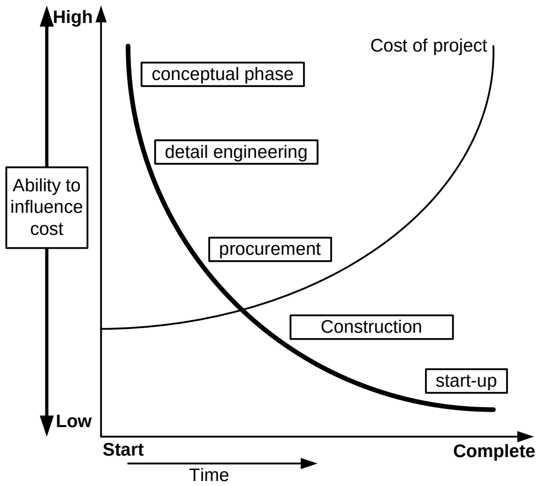

Figure 1: Ability to influence costs throughout a project life cycle.

Winch (2010) and Olsson (2000) describes construction as two chains. A project chain which describe the phases, and a product chain, illustrating the transformation from raw material to construction material used on site. The product chain has several tiers. Due to the amount of tiers, transactions costs can be high. In relation to phase transition the product supply chain is often changed or modified at this point. Knowledge management and transferability becomes important, which only is present when quite costly product supply chain management is applied.

Gap analysis approach (Winch, 2010; Winch et al., 1998) views construction as a service function, which implies that the product sold to the client not is a physical product but a competency to produce the right product. To manage the quality of the service delivered focus must be put at different conception gaps, cf. figure 2.

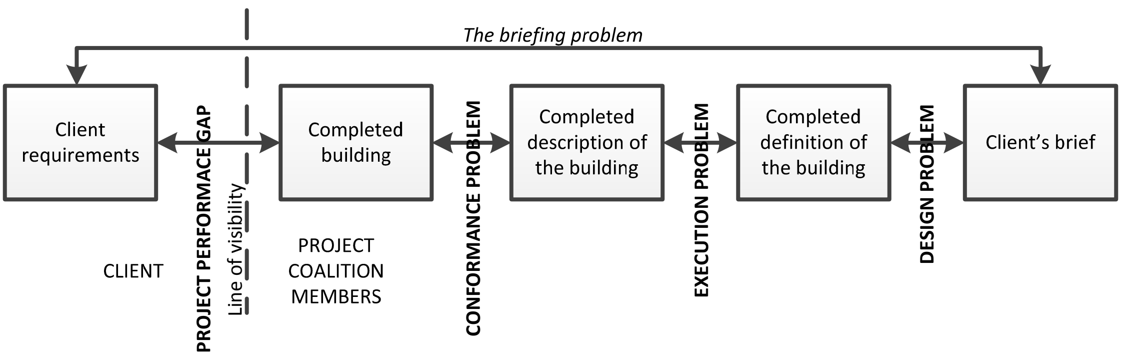

Figure 2: The briefing problem (Winch et al., 1998).

Project success can be achieved by minimizing the amount of surprises the client gets (due to conception gaps). High quality of the construction process equals the fraction of what is delivered to the clients versus what the client thought he was buying. Winch et al (1998) calls this conception gap the ‘project performance gap’. The smaller this gap is the less surprised the client becomes. The project performance gap is dependent of three central problems, cf. figure 2, arising early in the construction process. This view is in line with Wandahl (2004).

Thus, it differ which kind of problems to focus and solve in the different phases. This explains why there in a phase transition often is a shift in active project participants, which most likely increase the transaction costs.

Atkin et al. (2003) investigate which problems occur as a direct consequence of the fragmented construction process. It is pointed out that each decision is a compromise between different participants’, often conflicting, views on process and product. The need for these compromises combined with increased complexity requires a high amount of project coordination. In the concept phase the client’s requirements, needs, ideas and wishes should be disclosed. This process is very difficult due the amount of tacit knowledge and different types of requirements (Chen & Chuang, 2008; Matzler & Hinterhuber, 1998). It is unclear who takes ownership of distributing this knowledge from the concept to the design phase. A single person, e.g. the client, hardly can lift this task alone. Instead it is more likely that a group consisting of the client, architect and consulting engineers is capable of successful doing this transfer. Value lose will, therefore, arise partly due to the mentioned compromises, and partly due to the lack of knowledge transfer.

Other relevant theoretical frameworks could be organizational theory, theory of culture, and communication theory. However, these are not applied in this research. In total, the different theoretical frameworks points towards a wicked problem (Richard, 2005).

Now different theoretical frameworks usable for describing and analyzing the phase transition problem are present.

2. Methodology

This research is carried out as a qualitative research based on semi-structured interviews. It is an explorative hypothetic-deductive study aiming at obtaining increased knowledge of a partly unknown area. In total 9 respondents were interviewed, from which 6 all worked on the same construction project. Of the 9 respondents 4 were consulting engineers, 1 were client, and 4 were contractors. The 6 respondents from the same construction project were chosen, because a case-based approach offers additional insight.

Data from the interviews are combined with literature to test 8 posted hypotheses on phase transitions. The weakness in this hypothetic-deductive approach is that research tends to confirm hypotheses more easily than rejecting them. This because researcher often approach the case with an implicit bias. The counter approach in this research is firstly to make the bias explicit and by validating results through prior research results found in literature.

3. Results

In the following 8 hypotheses are described. All hypotheses concerns potential problems in the phase transition between design and construction. The hypotheses are developed through literature study and through interviews.

Value lose in phase transition between design and construction is due to….

1. *…bad communication and lacking cooperation*
2. *…low trust between project partners*
3. *…insufficient transfer of knowledge*
4. *…non coherent expectations*
5. *…lacking obligation form the client*
6. *…lacking focus on phase transition*
7. *…scare resource to apply in phase transition*
8. *…conflicting interest*

As mentioned in the methodology, hypothesis testing is based on interviews combined with literature.

Bad communication and lacking cooperation is recognized by all respondents. However, all respondents think that cooperation in construction in general is good, but when conflicts occur they are hard to handle. Cooperation between consulting engineers and contractors is pointed out as the most risky, because large conflicting financial interest is present. The conflict is often centred on extra work, compared to what is entailed in the final design. Several reports confirm this (EBST 2000a; Apelgren et al., 2005; Buch & Odgaard, 2010). Apelgren et al. (2005) identifies bad communication as a top five of stumble stones of construction projects.

A problem in the construction process is low trust between project partners, which among others is due to the temporary cooperation. All respondents' agrees that there in general is low trust between consulting engineers and contractors. This is mainly due to conflicting financial interest. The consequence is pressure on budget and time schedule. In 2000 the report "The future of construction" identifies low trust as the main barrier for development in construction (EBST, 2000a).

Insufficient transfer of knowledge when move from design to construction is a well-known problem. The knowledge transfer is often executed through project material, e.g. drawings, descriptions, models, etc., and through an initial project work-through meeting. All respondents agree that the transfer mainly is written, i.e. little oral communication take place. The European tendering rules is among other one of the main barriers here. Some respondents argue that it is hard, but outmost important, to transfer implicit values, thought, intentions and background for the final design. Interface problem is in EBST (2005) pointed out as a primary cause for failures in construction. Apelgren et al (2005) builds on by stating that meetings with contractors and consulting engineers for project work-through attain too little focus.

Non coherent expectations means that the different project participants have different, and some time incomparable, expectations to both the product and the construction process. Respondents agree that alignment of expectations not takes place. Some respondents argue that it is of special interest and relevance to have coherent expectations in terms of clear line of command and conflict solution models.

Lacking obligation from the client. In recent years a discussion of whether or not the client should act as a change agent is taking place (EBST, 2000b). Respondent do however think that the client already is involved satisfactory. It is also pointed out that non-professional clients cannot contribute to process development. All respondents agree that clients in general have a realistic conception of value for money.

Lacking focus on phase transition, is obvious. In construction focus is on the phases and not on the interfaces. Some respondents request governmental guidelines for how to handle phase transitions combined with opportunities offered in the European tendering regulation.

Scare resource to apply in phase transition. All respondents cannot remember one single project where dedicated budgets to handle phase transition was applied. Though, it is common for the client to budget the tendering process, but not a following period of communication.

Conflicting interest is the history of construction. All respondents have experiences with deliberate sub-optimazation of construction process with the purpose of increasing individual and company gains. Grønkjær (2005) even put forwards a guideline on how to discover and take advantage of contractors' extra work.

Table 2 concludes on the hypothesis testing, and guides the following narrowing of research scope.

Table 2: Hypothesis testing

H1: bad communication and lacking cooperation	*True*
H2: low trust between project partners	*True*
H3: insufficient transfer of knowledge	*True*
H4: non coherent expectations	*True*
H5: lacking obligation form the client	*False*
H6: lacking focus on phase transition	*True*
H7: scare resource to apply in phase transition	*False*
H8: conflicting interest	*True*

To continue work on the 8 hypotheses, relations are discovered through Cause-Effect Analysis. This is applied for selecting the most significant hypothesis to put in focus and work with. The result is illustrated in figure 3, which implies that only hypothesis 3 “insufficient transfer of knowledge” will be in focus in the following discussion of the results.

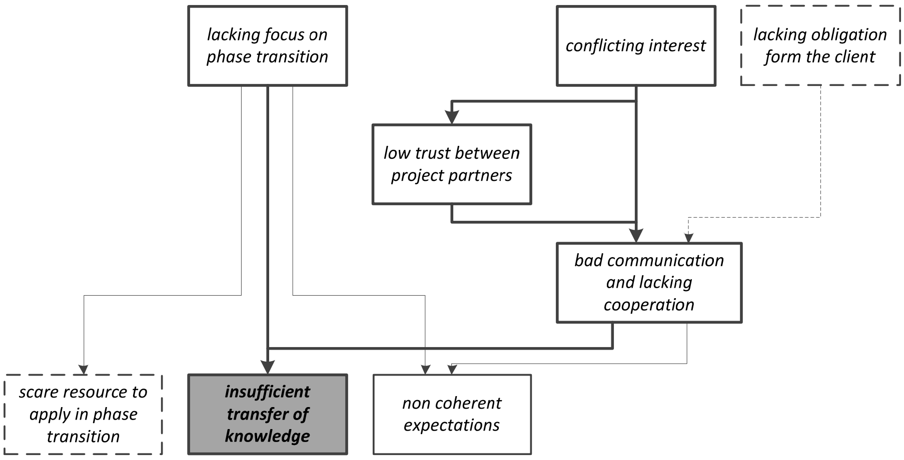

Figure 3: Cause-Effect Diagram. The bold lines mark the main Cause-Effect chain. Dotted lines mark rejected hypothesis.

4. Discussion

Transfer of knowledge and information between consultants and contractors in the transition between the design phase and the construction phase, i.e. tendering, is limited by the tendering regulations. When a project is in tender, a contractor can ask question and give comments to the client and his advisors. The tendering regulation demands, however, that the client forwards all questions and answer in its whole and on the same time to all bidding contractors. The principle is referred to as the equal treatment of tenders (Craig, 1999). Therefore, contractors often withhold question and comments, due to competitive advantages, i.e. competitors should not be informed of weakness in the tendering material. Current tendering regulation could hence be seen as a barrier to communication in phase transitions.

Both operational and non-operational information needs to be exchanged. Operational information is information required to perform a given task. An example could be a painter. He needs to know which door to paint, and in which colour. The painter already holds additional operative information, e.g, he knows how to paint a door. Non-operational information is not needed to perform a task, but can be of value. It could be useful for the painter to know why the client wants to paint the door red, etc. Non-operational information increases the interest in the task. Information on its own is not value adding. But when an individual interprets information it becomes knowledge, e.g. the information is contextualized (Nonaka et al., 2000). To types of knowledge exists, namely explicit and tacit knowledge. Emmitt & Gorse (2003) argues that by doing the design, consulting engineers and architects will possess tacit knowledge which eases their interpretation of the project material compared to the contractor who until the tendering material is received did not know of the design.

The consulting engineers have large knowledge about the project, and the main part of this knowledge is transferred into project material, which again is handed over to tenders, and hence founds the contractors' operational knowledge. The client can provide designers and consulting engineers with non-operational knowledge, e.g. motivation, background, preconditions, etc. which increases the overall understanding for the project. When a contractor is awarded a job in tender, the project material is his operational information. This information the contractor then contextualise into knowledge. If the contractor has insufficient competencies and experience, there might be part of the operational information that he cannot interpret. The contractors' knowledge on buildability is his main tool in this process. In current state of construction, a contractor most likely does not receive any non-operational knowledge from the consulting engineer. Both this current state and a required future state of knowledge transfer are illustrated in figure 4.

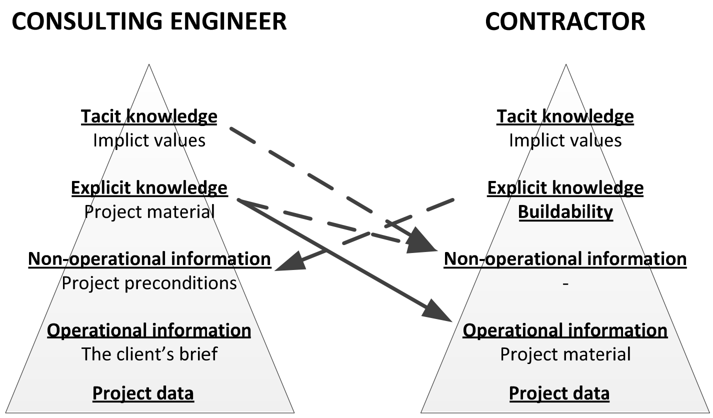

Figure 4: Optimal knowledge and information transfer (dotted line illustrates desired future state).

At current state, only the consulting engineer's explicit knowledge is transferred to contractors at the transition between design and construction. Consulting engineers has furthermore an explicit knowledge on project preconditions and design thoughts. This is not transferred to the contractor, which would have been valuable non-operational knowledge. There is also a lack of knowledge transfer from contractor to consulting engineers. A contractor possesses valuable explicit knowledge on buildability and construction methods, which could be useful for designers.

5. Conclusion

This research highlights inter-phase issues as a missing focus point in to-days construction practice. Phase transition is investigated both theoretically and empirically. A phase transition is defined as a time in a project lifecycle when the purpose shifts, when there is a change in active project participants, and when new sub-project activities and purposes begin.

8 hypotheses is put forward and tested qualitative by means of conducting 9 interviews with practitioners. 2 of the hypotheses are rejected while 6 remain. By investigating dependencies of the 6 hypotheses, the main problem is identified as "insufficient transfer of knowledge".

In general more information and knowledge sharing between contractors and consulting engineers is needed. Both in terms of operational information and non-operational information. The need for knowledge sharing is two-ways, but is mainly lacking from consulting engineers towards contractors.

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Communication in construction project meetings: Information loops and decision making logics

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Abstract

The basic objective of this paper is to use original data from observation of communication in mission critical project meetings, in order to assess what particular communicative structures project management actually relies on, in the management of construction projects. The specific idea has been to assess the very basic and simple theoretical model of management moderated project communication, information transfer and decisionmaking, which Winch (2010) uses as a cornerstone in his information processing approach to construction project management.

The analysis undertaken here gives results that support the claim Winch makes, that generic information loops are important in construction communication. It is found that the structure of his model is important for understanding the function of management in construction projects. However, the analysis also indicates that another type of information loop with higher complexity in many cases is more important than the generic information loop.

It is found that generic loops and more complex loops differ in terms of the basic decision making logic that they embody. Generic loops are associated with an iterative logic, while complex loops embody recursive logic. Considering the actual content of communication, it is argued that the logics of generic and complex information loops are recognized as different also by meeting participants themselves. Pursing diverging interests in specific situations, they can be shown at times strive to influence the mode of communication, either in the direction of generic loops, or towards more complex communicative structures.

Keywords: Project management, Communication, Construction, Decision making, Information loops

1. Introduction

The literature on project management in construction is large and growing. Reviewing this literature, Smyth and Pryke find that approaches to project management (PM) can be grouped into several distinct categories, or paradigms, and find that these are complementary, rather than substitutes. Two main paradigms are the traditional and the information processing approaches (Smyth and Pryke, 2006: 22 and 2008: 1). In an influential textbook on construction management, Graham Winch has developed an approach to PM consistent with the information processing paradigm. In his perspective, construction project management fundamentally concerns decision making in dynamic situations marked by a paucity of adequate information (Winch 2010).

Winch develops his own information processing approach without making a radical break with mainstream – traditional – approach to PM (as codified for instance in the Project Management Body of Knowledge, or PMBOK. It will be argued here that Winch creates a theoretically more powerful conceptualization than what is found in PMBOK, and that he offers a resolution of the long standing paradox in the traditional approach, regarding the relationship between careful planning and flexible execution.

Communication in construction has until relatively recently received scant attention from researchers. Some notable exceptions are early contributions made by scholars from Great Britain (for example Higgins and Jessop 1965). Over the last few years, however, communication in construction has been analysed much more comprehensively. The existing literature has been reviewed and discussed for instance by Emmitt and Gorse (2003), who themselves have contributed significantly to advancing the knowledge in the field. They have investigated the nature of communication processes, and preconditions for effective communication in construction projects (Emmitt and Gorse 2003, 2007). Also, Gorse and Emmitt 2003 as well as Otter and Emmitt (2008) in separate papers have discussed the appropriateness of diverse methods for research on communication. They point out that only a small body of work exists that bases analyses on observational data, rather than interview data. Dainty, More and Murray (2006), also with a basis in research in a number of different construction projects, have made a significant contribution to the analysis of construction communication, why it is important for performance, and what factors influence the efficiency of communication in the context of construction. Another important, recent contribution to this research area is Gluch and Räisänen (2009). Recognizing the need for original observational data of communication, they have done observation of communication and interaction in construction, and supported this with video recording. In this way, they have for instance been able to document that there are discrepancies between what is said and what is actually done in construction projects. Hence, they have highlighted the limitations of research that focuses single-mindedly on communication, ignoring more material aspects of what is going on in construction projects.

This paper has been written as a contribution to the empirical analysis of communication in construction and in the management of projects. The analysis is based on data from direct observation of communication in construction projects, and in project meetings. The contribution that the paper makes is complementary to much of the research on communication cited above, which engage critically in assessing factors such as psychological, social and organisational, and the impact these have on communication, as well as on the performance of construction projects. The intended contribution made in the present paper is more specific than this, and more limited. The basic objective here is to use original and rich data from mission critical, live project operations, to assess what particular communicative structures project management actually relies on when managing construction projects. The specific idea has been to assess the very basic and simple theoretical model of management moderated project communication, information transfer and decisionmaking, which Winch (2010) uses as a cornerstone in his information processing approach to construction project management.

The analysis undertaken here supports the claim Winch makes, that generic information loops are important in construction communication. It is found that the structure of his model is important for understanding the function of management in construction projects. However, the analysis also indicates that another type of information loop, with higher complexity, in many cases is more important than the generic information loop.

It is found that generic loops and more complex loops differ in terms of the basic decision making logic that they embody. Generic loops are associated with an iterative logic, while complex loops embody recursive logic. Considering the actual content of communication, it is argued that generic and complex information loops are recognized as different also by the participants themselves. It is demonstrated that participants, pursing diverging interests in specific situations during construction meetings, at times strive to influence the mode of communication, either in the direction of generic loops, or towards more complex communicative structures.

2. Generic information loops and iterative decisionmaking

Mainstream PM literature stresses the importance of making comprehensive and robust project plans, and at the same time argues the need for flexibility and the ability to deal with surprises and abrupt changes (Morris and Pinto, 2007, pp. ix-x): One the one hand, the basic project management skills include the ability to plan work, give clear instructions how to proceed, control operations, and make sure that progress is made according to plans. On the other hand, project managers must also be able to take actions that are outside the framework of established plans, as information is invariably incomplete and surprises unavoidable. Planning is essential, but all the same, the project in itself is a dynamic, non-linear process impregnated with uncertainties and unpredictability. This paradox is a source of controversy in the PM literature, but also a source of continued interest in research of construction project management (See, for instance, Williams, 1999, 2005; Bresnen et al. 2005, Cicmil et al. 2006, Winter et al. 2006, Chan and Räisänen 2009).

The paradox is addressed in a theoretically interesting way by Winch (2010). In his volume on project management in construction, communication is placed at the centre of analytical attention. The project manager is construed as the nexus of everything that is going on inside and around the building site. Winch draws on Giddens' sociological theory of structuration, which is a general sociological theory attempting to bridge the gap between "structuralist" thinking on the one side, and "voluntarist" thought on the other (Giddens 1984).

With the help of structuration theory, Winch can show that there has to be an on-going interaction between the structure of plans and programmes, and the flow of individual action and process events in construction. The end product in construction is gradually, interactively and reflexively shaped, and both the structures of plans and the unpredictability of events and actions are necessary parts of the process. Communication is the medium in which structuring takes place, and in Weick's sense (Weick 1995), communication embodies both information transfer, and the active construction of meaning.

It is in this theoretical context that Winch introduces the concept Generic Information Loops (GILs), which serves amongst other things to make evident that he avoids a radical break with mainstream PM theory. While the successful construction project is an evolutionary outcome and a creative achievement, the project manager plays a crucial coordinating and leading role, monitoring operations, updating work plans and giving necessary instructions about how to progress operations, in planning and design as well as on-site, in the actual building efforts.

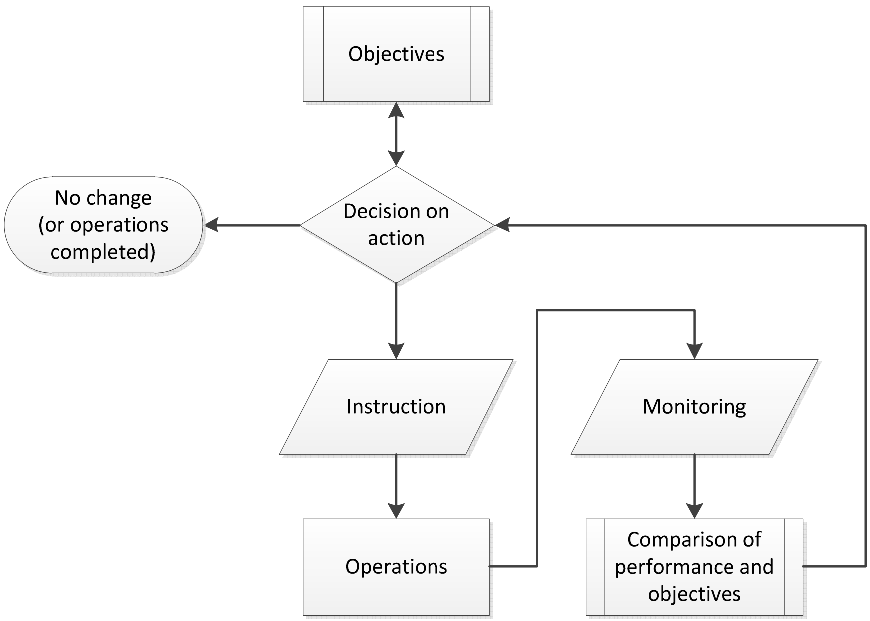

Figure 1: Generic information loops and iterative decision-making

GILs embody a circular flow of information in what is in effect a control loop. This control loop logic is represented in figure 1.

The key function of management is to compare operational performance with operational goals, and based on the outcome of this comparison, give adequate instructions regarding operations. The overall logic of decisionmaking in this scheme is iterative. Since information is invariably imperfect, decisions must take stock of available information and devise guidelines for action, which seem reasonable in lieu of the information that is currently available. As work progresses, further information becomes available, also on the real effects of decisions made earlier. Hence, it is important continuously to evaluate the current situation, and if necessary to formulate updated operational goals.

According to Winch, GILs – where information flows from decisions to operations and back to new decision-making – are fundamental in the project as a whole, and relevant in all phases of construction. He points out that the time it takes to make a complete cycle varies to a large extent (Winch, 2010, p. 181). Some cycles are nearly as long as the project itself, while others are very short.

3. Research design

The design of the research reported in this paper encompasses a two-step strategy of empirical investigation. In the first step, a comprehensive mapping of a major construction project was undertaken, over a period of four years. The participants in this project and their roles in the project were mapped, on the level of individuals and organisations. This mapping of actors and activities was longitudinal in nature, corresponding to the methods for longitudinal data collection in innovation projects laid out by Poole, Van de Ven *et al.* (2000). Mapping of actors and logging of events had to be eclectic to some extent, as the overall project was too large, long lasting and complex to be covered comprehensively.

The project studied was owned by a major Norwegian contractor, and the project was observed from the very early stage of planning the overall features of the project outcomes and the business model underlying it. The project was stalled for several months in 2009 due to economic uncertainty. Observation of the project continued as soon as it again was made active, and observation continued until a major part of the project was completed in 2011. During planning stages, observation was primarily undertaken in project meetings and by way of interviews. In the later stages, most kinds of meetings were observed, the building site was visited regularly, and throughout the period of observation, interviews were made with workers and managers on site, as well as with architects, engineering consultancies and technical subcontractors off site.

The focus in this first phase of data collection was to gain an understanding of the diverse people and organizations taking part in the project, their mission within the overall project, their perception of their own role and the roles of others, and the key challenges they had to cope with in order for their part in the project to become a success. The understanding gained of the project and the contributing parties was used actively in the second step of empirical research. Among the more than 20 project meetings that were recorded and transcribed *verbatim* in the course of the overall data gathering effort, the transcription of one progress meeting was singled out for closer scrutiny. The complete transcription of the meeting was coded, using a coding scheme developed interactively, during the first phase of data collection and in particular in the second phase.

In the actual flow of communication, generic information loops are not salient features. As understanding of what was going on improved, it continued to be an open question to what extent GILs are important. The coding scheme that was developed helped coming to grips with this question.

4. Generic information loops (GILs)

In his model of GILs, Winch depicts a step-wise and evolutionary process where three kinds of information are cycled: information on goals of efforts, information in the form of work instructions, and information on results and outcomes stemming from observations of performance (Winch, 2010, pp. 6-8 and 180-182). In meetings, it was found that some sequences of statements were of this kind. First, people in meetings talked about the project goals, usually because they were concerned with what was to be made and how this had to be done. Second, some of those involved in the meeting were concerned with what instructions to give to the workers. Finally, statements were often made, expressing concern with what was actually taking place at the site, in terms of work operations.

In this way, observations could confirm that there were sequences of statements within the stream of communication that had to be conceived of as elements of GILs. In the coding scheme, three types of statements were specified, that formed the starting point of a more comprehensive coding scheme:

- Goal statements (GoS)
- Instruction statements (IS)
- Monitoring statements (MS).

The software system NVivo 9[1] was used in the coding of the complete transcription of the progress meeting selected for more detailed analysis. This particular meeting was selected on the basis of being a typical and ordinary meeting, and because it was a progress meeting, which typically is more concerned with administrative issues, logistics and organization, than in solving design problems or deciding particular construction details. Hence, the likelihood of finding elements of generic information loops was considered to be high in this kind of meeting.

While not immediately visible, work on coding in NVivo helped to determine that GIL structures actually could be found in the communication of the meeting. It was found, for example, that the site manager often asks and elicits responses about the state of affairs in a particular area; how far work has progressed, what the problems are, etc. These are what in the GIL-model are defined as Monitoring Statements (MS). The site manager, or some other person, often proceeds to state what has to be done, in what timeframe, etc. This, however, may take the form of a number of related statements made by several of the participants in the meeting, as it was found in this meeting and other meetings in the same project, that the site manager often relies on others in remembering and expressing what the actual work programme and detailed plans are. In either case, statements of this kind had to be coded as Goal Statements (GoS).

In addition to this, it was found that after considering the state of affairs on site, and repeating what goals were to be achieved, a number of statements were made about what was to be done, how, by whom, and when. Such statements were often, but not always, made by those who have authority to

[1] http://qsrinternational.com/products_nvivo.aspx

decide, in other words by the site manager, or the project manager. Irrespectively of who uttered them, and in what order statements were made, these statements were coded as Instruction Statements (IS).

5. Complex information loops (CILs)

In GIL-model of project communication, project goals are simply assumed to exist. The model makes it clear that goals are subject to being changed, in the light of new understanding of the situation emerging in the course of the project itself. But the model itself does not explain how the original goals are set. In the research reported in this paper, analysing project communication and interactions from the very beginning of a project, it has in some important cases been possible to document how goal setting actually happens. It has been found that goal setting is a salient feature of engineering and design meetings and in other meetings where key stakeholders such as the architect, the builder and the contractor engage in negotiating the actual content of projects. But it has also been found that goal setting can happen also in progress meetings.

Negotiations of what a particular project is about, what should be achieved and how, have been observed frequently, and is a major element of communication in projects. These negotiations involve creative opening of opportunity spaces, and not only negotiations on how to balance diverse interests against each other. From the very outset, when the first overall design was drafted, resources mobilized and a business plan for a new construction project is developed, different people and firms were involved, and were required to come up with new ideas for how best to realize the ambitions and requirements of the builder.

What went on was at the same time a problem-generating and a problem-solving process. Involved parties were found to act as attorneys for their particular knowledge fields and professional interests. While general problems often entailed the efforts of many specialists in order to find a solution, it was often observed that sub-problems are singled out that has to be addressed to only a single category of specialized knowledge. Hence, discussions concerning complex problems were often interrupted when sub-problems were specified that needed the involvement of others to be solved effectively. Such occurrences represent interruptions in a meeting, but seen in the context of information flow, what happens is a branching off into a new branch, or a new sub-loop.

Observations have showed that participants in meetings often try resolve issues immediately to avoid the interruption that the branching off entails. Meeting participants come up with creative ideas that may make a detour dispensable. It was found that statements made in this kind of situation aptly could be labelled as ‘generative’. *Generative Statements* have in line with this been defined as statements that encompass proposals for solutions, ideas about how things ought to be, and so forth. These statements mobilize, present new opportunities, and may open up an opportunity space that was not perceived before.

A second category of statements often observed in the context of problem formulation and problem solving were statements that in effect took stock of the situation as it was seen and understood by the participants in the meetings. These were labelled *Factual Statements*. This group encompass both positive statements of matters of fact as they are seen, and questions asking what the facts are.

It was found that there is a strong resemblance between Factual Statements (of CILs) and Monitoring Statements (of GILs). It proved to be important to distinguish between the two, however, as a certain kind of bickering occurred repeatedly in the communication in meetings, that concerned the active negotiation of this particular difference. Participants in meetings would, often implicitly and indirectly, hint to the fact that the issue at stake was not a matter of fact statement of what had been done and what remained to be done, but a real negotiation of what ought to be done, as the current situation could not be taken to represent a situation planned for and expected. Typically, it was foremen who challenged project- or site manager in this way.

A third group of statements observed frequently encompasses evaluations, interest representations, commitments to priority setting, etc. This category was in the coding scheme labelled *Evaluation Statements*. These were found to be very common, which was not surprising, as the understanding of what was going on increasingly took into account the complexity of decision making, in situations where many relevant and often contradictory concerns have to be balanced against each other. This category also had to include statements emanating from controversies, such as between the architect and the builder, where the former wished to give priority to aesthetics while the latter typically paid more attention to the incurred costs of materials and more complex building operations.

A fourth group of statements observed were labelled *Concluding Statements*. These were found to have the opposite effect of generative statements: They produce discursive shifts towards synthesis, compromise or simply selection between alternatives. Importantly, Concluding Statements were found not necessarily to be conclusive. It was only when some kind of convergence was achieved that concluding statements could produce a final conclusion – an explicit decision. Such statements that represent termination points of discussions are here referred to as *Decision Statements*.

To sum up: Observations of communication in construction project meetings in one particular construction project have formed the basis for an analysis of communication resulting in a typology of different types of statements. It has been found that three kinds of statements can be singled out as constitutive of what Winch has called Generic Information Loops. Five other types of statements have been singled out, that have been found typically to be related to problem formulation and problem solving, and it is here proposed to label the communication structures that they part of as Complex Information Loops (CILs). The elements of CILs, then, are:

- Factual statements (FS)
- Generative statements (GS)
- Evaluative statements (ES)
- Concluding statements (CS)
- Decision statements (DS).

A large number of statements are made in project meetings that are part of sequences of communication of this kind, and is related to negotiation and problem solving. This kind of communication is, as a matter of routine, decomposed into one or more sub-problems. Solutions found to sub-problems are, or can be, fed back into the more complex problem-solving effort, creating a communication structure that is nested, as is shown in figure 2.

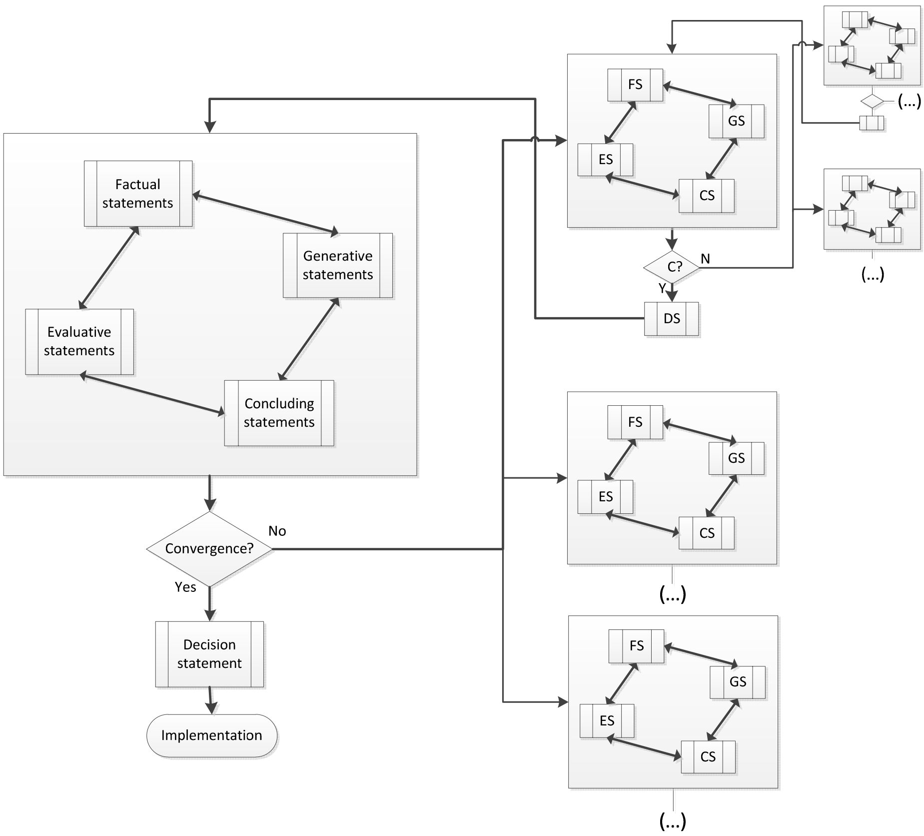

Figure 2: Complex information loops and recursive decision-making

It is the statements labelled as Decision Statements that contain whatever conclusion is produced in the communication. These statements serve to link communication regarding sub-problems, to the overall communication on more complex problems. Decision statements feed back into higher level decision-making loops. However, recursive loops do not have to end up in an explicit decision. It has been observed repeatedly that there is no guarantee that any decision-making loop actually does produce an explicit decision.

6. Branching statements and the interplay of generic and complex information loops

As explained earlier, coding of all statements made in one particular progress meeting was coded in line with the above typology, using NVivo 9. Relevant information, for example regarding who made statements, their age and educational background, what companies they worked for, their role in the project, etc. was also coded into the NVivo database. Only the overall result of the coding, in terms of the typology developed, is presented here.

Table 1 shows that over 80% of all statements made during the 2,5 hour meeting could be coded as either part of a generic communication structure, or as part of a complex communication structure. With reference to the GIL model introduced by Winch, it is significant that only about 1/3 of all communication in the meeting was of the generic kind, while more than 40% was part of the complex communication model introduced in this paper.

Table 1: Statement types, communication in progress meeting

		Coverage	Items
3	**Coded communication (3.1 + 3.2 + 3.3)**	**81,5 %**	**1078**
3.1	**Generic information loops (3.1.1 + 3.1.2 + 3.1.3)**	**35,2 %**	**436**
3.1.1	*Goal statements (GoS)*	*5,2 %*	*65*
3.1.2	*Instruction statements (IS)*	*6,2 %*	*85*
3.1.3	*Monitoring statements (MS)*	*23,8 %*	*286*
3.2	**Complex loops (3.2.1 + 3.2.2 + 3.2.3 + 3.2.4 + 3.2.5)**	**43,3 %**	**570**
3.2.1	*Factual statements (FS)*	*20,2 %*	*215*
3.2.2	*Generative statements (GS)*	*7,4 %*	*67*
3.2.3	*Evaluative statements (ES)*	*4,9 %*	*68*
3.2.4	*Concluding statements (CS)*	*8,8 %*	*156*
3.2.5	*Decision statement (DS)*	*2,0 %*	*64*
3.3	**Branching statements (3.3.1 + 3.3.2 + 3.3.3 + 3.3.4)**	**3,0 %**	**72**
3.3.1	*Branching to complex loop (BCL)*	*1,3 %*	*36*
3.3.2	*Branching to generic loop (BGL)*	*0,7 %*	*17*
3.3.3	*Branching to complex loop externally (BCL-E)*	*0,9 %*	*17*
3.3.4	*Branching to generic loop externally (BGL-E)*	*0,1 %*	*2*

Beyond this, it was found that a group of statements appeared as belonging to neither of the two groups, but were statements that were found to have the purpose of moving the logic of communication from one type of logic to the other. The most frequent of these kinds of statements were statements that served to transform GIL communication to CIL communication. Typically, this was made by foremen who wished rather than simply accepting orders, to appeal to management to reconsider and to accept engaging in negotiating aspects of the work, for instance what should be done, by whom, when, or in what way. Also the opposite situation was observed: In these cases it was typically the site manager who wished to avoid discussion, leaving it to the construction workers themselves to sort out difficulties, without opening up for negotiating goals and plans for progress.

7. Conclusion

The contribution of the analysis in this paper is based on the analysis of original observational data on communication in construction, and in a selected progress meeting taking place in the most intense phase of a construction project, when a large number of trades are already involved in the operations on-site, but detailed engineering and design is still on-going.

The point made here is, however, theoretical in nature. It has been shown that when construction communication is assessed in terms of information loops and decision making logics, simple control loops and iterative decisionmaking do play a role, and are important aspects of the management function in a project. At the same time, however, it has been shown that more complex information loops and recursive decision making logics are equally important, even in meetings that one would assume are primarily preoccupied with giving instructions and monitoring performance in operations; namely progress meetings. The result here is consistent with a body of research indicating that management plays an important role in projects in facilitating communication, in involving others in negotiations, in effect, delegating the task to establish adequate grounds for decision-making by relying on distributed intelligence and delegated decisionmaking, rather than on insisting on hierarchical control and centralising the powers of command and control.

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A Proposed Methodology for Studying the Potential Application of Earned Value Management in Construction Projects in Spain

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Abstract

Project management has been considered practically non-existence in the Spanish construction public sector and slowly trying to make its way into the private sector. Taking into consideration the pace of convergence of construction project management practices around the world, it is becoming evident that there is a serious need for the Spanish construction industry to further embrace project management into its practices. The Earned Value Management (EVM) can be considered a simple method in managing construction projects incorporating the most fundamental principles of project management concepts. Thus, adapting EVM in the Spanish construction industry can be perceived as an important step to bring the industry up to speed with the rest of the world in the context of construction project management to increase its competitiveness in the world. Aiming to do so, a research project has been set to study the potential of applying EVM to better manage construction projects in the Spanish construction industry. Designing and developing research methodology in academic research has been considered one of the most important activities to be undertaken by the researcher(s). Thus, a robust research methodology will almost certainly help the researcher(s) in adopting good practices and turning out meaningful outcome from the investigation. Taking into account the current discussions on the potential gap between academic research in construction and industry based practitioners in making use of the research outcome; this paper discusses the research methodology of the research project. The advantages of mixed methods applied, consisting in-depth interviews with and distribution of questionnaires to construction project management practitioners in the Spanish construction industry, are mapped to the aim and objectives of the investigation. The data collection procedures and data analysis are discussed and aligned to the intended outcome of the research project. The outcome is expected to provide advice to the Spanish construction industry and its practitioners in improving the management of construction projects in Spain.

Keywords: Construction, Earned Value Management, Project Management, Research Methodology, Spanish Construction Industry

1. Introduction

Following its initial development and use in the defence and construction industry in 1950s, mainly in the United States, project management has continued to grow and develop into a multi-disciplined profession with its distinctive tools and techniques. In principle, the tools and techniques have assisted project managers in monitoring all the current status measurements against the desired values (as set out in the project plan documents) at all times during the course of the project. Aiming to do so and to improve practices of managing the process, project management has been gaining momentum in dealing with management of projects (Winch, 2002). However, in a complex project (such as a construction project), there exist many variables contributing to its status. The intrinsic complexity, uncertainty and dynamics of most construction projects have resulted in difficulties for the management of these projects (Nguyen et al., 2004). Furthermore, the continuous demands for various requirements, such as speed in construction, cost and quality control, health and safety, and so on, have resulted in a rapidly spiralling increase in the complexity of construction projects (Gidado, 1996). As the work progresses on a number of activities conducted in a simultaneous manner, it has been found more difficult to monitor and review the status of the project due to its multidimensional nature (Burke, 2006). Thus many project managers may find it increasingly difficult to monitor and measure the true interpretation of the current status of their projects. Actual status may be measured through devices such as reports and progress reports. However, the potential problems remain concerning the accuracy and the time delays of such reports. The desired status is also continuously changing as the project progresses as the plans will be continuously evolving and the revised plans will be part of the dynamics.

Regarded as a project management technique that embodies the most fundamental principles of project management in practice, the system of controlling project discussed in this paper is the one known as the Earned Value Management (EVM) method. EVM was developed mainly to show the project managers not only the cost of the work performed so far but also the value earned by that work. In Spain, the concept of project management has been reported as gradually and slowly implemented (Pellicer and Victory, 2006). However, project management has been considered practically non-existence in the public sector (mainly construction) and slowly but painfully, trying to introduce itself into the private sector. Taking into account the pace of convergence of practice in Europe and the world, there appears to be a significant need for Spanish construction industry to embrace the project management into its practices. Thus, adapting EVM in the Spanish Construction Industry can be perceived as an important milestone to bring the industry up to speed in the context of project management which will increase its competitiveness in the world.

In light of the ongoing discussion, a research project has been set hosted by the Department of Construction Engineering, Universitat Politécnica de Valencia, Spain. The aim of the research project is to investigate the potential introduction of EVM in the Spanish construction industry. The research project intends to study the contractors in the Spanish construction industry with the view to introduce EVM to the industry.

In order to satisfy the aim, the following objectives have been set:

- to explore the appropriateness of adapting EVM in the Spanish construction industry,

- to analyse the readiness of the firms, human resources and infrastructure (including legislation).

- to recommend the most optimum but realistic way to adapt EVM in the contracting firms operating in the Spanish construction industry

2. Earned Value Management (EVM)

Since its original embryonic inception during the 1960s in the United States, Earned Value Management (EVM) has becoming a standard tool in the project management field. EVM has been defined as a fully integrated project 'cost-and-schedule control' system which allows through trend analysis the formation of 's' curves and costs/schedule variances (Potts, 2008). The Project Management Institute defines Earned Value Management (EVM) as "a management methodology for integrating scope, schedule, and resources, and for objectively measuring project performance and progress". Performance is measured by determining the budgeted cost of the work performed (i.e. earned value) and comparing it to the actual cost of the work performed (i.e. actual cost). Progress is measured by comparing the earned value to the planned value (PMI, 2004, p. 359).

By 1990s, EVM has been widely adopted in the United States, particularly in the defence and aerospace industries. The Department of Defence in the USA developed guidelines for the adoption of EVM, and has been active in both promoting and requiring the use of EVM on its projects (Fleming and Koppelman, 2005). However, the capabilities of EVM to better control projects has also been realised in other parts of the world. A survey (NAO, 2005) revealed that EVM is mandatory for large projects not only in the USA, but also in Australia, Sweden and the UK. In other parts of Europe, other than Sweden and the UK, there has been little evidence of adaptation of EVM.

The earned value of the work performed on a project is the cost that the estimator attached to that work when the project budget was defined. There are 3 main components: PV, EV, and AC.

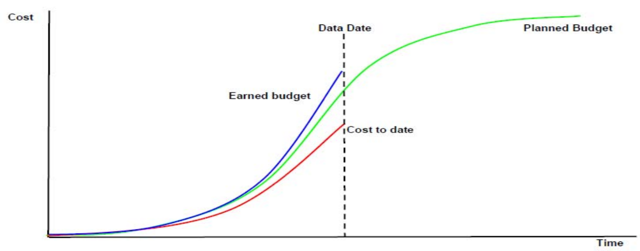

Figure 1. The basic components of EVM

The budget is known as the Planned Value (or previously BCWS). The progress to be achieved in relation to the budget is known as the Earned Value (or previously BCWP). EV tracks all the works that have been performed so far (progress) based on the original project budget (PB). As the project progresses, the Actual Cost (or previously ACWP) can be monitored by collecting data on the incurred costs of the labour and materials used by the project so far. By comparing PV, EP and AC, we can present the Cost Variance (CV) and Schedule Variance (SV) of the project being monitored. The ratio EV/PV is also known as the Schedule-Performance Index (SPI). The ratio EV/AC is also known as the Cost-Performance Index (CPI). The Estimated Completion Date (ECD) will depend on what assumption the PM chooses to make about the rate of working for the remainder of the project.

ECD = Total duration / (EV/PV)

The Estimated Cost of Completion (ECAC) will depend on what assumption the PM chooses to make about the cost of work still to be performed. One assumption is that the work still to be performed will be done at the budgeted cost. A more realistic assumption is that the remaining work will be performed at the same cost/budget factor that has been observed in the work performed so far, therefore

ECAC = PB / (EV/AC)

Following this, the Cost to Complete (CTC) can be calculated:

CTC = ECAC – AC

3. The Spanish Construction Industry

Prior to the global financial crisis, the construction industry has been considered one of the most dynamic sectors of the Spanish economy in terms of both job creation and production. 2007 saw the end of the long phase of expansion enjoyed by the Spanish economy in the previous decade and the beginning of an inevitable adjustment in the real estate and, consequently, in the construction sector. The value of construction domestic output in nominal terms reached €199,300m in 2007. The construction industry's importance in the Spanish economy can be represented by the fact that it provides work for approximately 2.6 million workers, which is 14% of the country's work force. A breakdown of the total activity for the construction industry yields the following description. House construction rose by 2% to represent 31% of the industry's total production. This increase was mainly sparked off by the increasing demand of non-residents investment buyers, coupled with low interest rates. Non-residential construction raised by 2.5%, tallying 15% of total activity mainly influenced by two fundamental factors, the uncertainty surrounding the international situation and the global slowdown. Civil engineering managed a 7.9% increase, reaching 24.8% of total activity, due mainly to increasing demand from the public sector, which was particularly boosted by the Ministry of Public Work's Infrastructure Plans and the Environment Ministry's Hydrological Plan. Finally, renovation and restoration work grew by 6.5%, representing 23.8% of total production in the Spanish construction industry. The importance of the construction industry in Spain relative to the European Union zone can be illustrated by the relatively high proportion of Spanish construction industry as a percentage of GDP in comparison to other EU countries as follows (SEOPAN, 2007): Ireland (19.2%), Spain, (17.9%), Portugal 15.6%, Finland (14.6%), Germany (10.2%), France (10.9%), Italy (12.7%), the UK (10.5%) or the Netherlands (12.9%). This makes Spain one of the largest European markets in construction.

The contribution of its construction industry to the GDP in Spain is among the largest in the Europe (SEOPAN, 2007). Therefore, improvement in its construction industry will undoubtedly benefit the country in a large scale. In Spain, the concept of project management has been reported as gradually and slowly implemented (Pellicer and Victory, 2006). However, project management has been considered practically non-existence in the public sector (mainly construction) and slowly but painfully, trying to introduce itself into the private sector. The main issues in the Spanish construction industry, particularly in the public sector have been identified as inadequate prequalification system of contractors and designers, insufficient training of public servants, political considerations prevailing over real needs and, mainly, an insufficient PM maturity (de la Cruz et al., 2006). Whilst this is exacerbated by the intrinsic characteristic of the management style of Spanish managers that rely heavily on ad-hoc approaches and generally rejects planning (Aram and Walochik, 1997). More specifically on the relatively lower level of project management maturity in the Spanish construction industry public sector, this can be linked to EVM. Development of an integrated performance management baseline, such as EVM, can be very challenging for organisations with a low level of project management maturity (Bower, 2007). Thus implementation of EVM requires a cultural change (Christensen, 1998) to upgrade the project management maturity level in any organisations. Mainly defined as a concept that is trying to measure the maturity of organisations in managing their projects, various scholars claimed that project management maturity can be used as a way of achieving competitive advantage (Jugdev and Thomas, 2002). EVM embodies the most fundamental principles of project management in practice. Thus, adapting EVM in the Spanish Construction Industry can be perceived as an important milestone to bring the industry up to speed in the context of project management which will increase its competitiveness in the world.

4. The Proposed Research Methodology

Research methodology refers to the principles and procedures of logical thought processes which are applied to a scientific investigation (Fellows and Liu, 1997). Thus research methodology can be considered the overall strategy to achieve the aim and objectives of the research. In order to do so, the research methodology in this research has been designed following the principal of mixed methods approach. There is a strong suggestion within the research community that research, both quantitative and qualitative, is best thought of as complementary and should, therefore, be mixed in conducting research (Onwuegbuzie and Leech, 2005). This mixed approach utilises both quantitative and qualitative research methods to explain a phenomenon. Even though, the domination of one method cannot be avoided, the other will perform as supportive method (Creswell, 1994). The complexity of research can be tackled using this approach is normally considered high which made it suitable for more realistic research in gaining a more holistic understanding of a phenomenon (Robson, 1993).

The selection of the right strategy can be influenced by the nature and the objective of the research. Yin (2009) addressed three conditions that a researcher has to fulfil in order to choose the correct strategy: (1) the type of research question posed; (2) the extent of control a researcher has over actual behavioural events; and (3) the degree of focus on contemporary events. There were five major research strategies considered in this research as follows: experiment, survey, archival analysis, history and case study. Heavily informed by the literature review, questionnaire survey and interviews involving construction project management practitioners in the Spanish construction industry have been selected for this research mainly in relation to the aim and objectives of the research. Table 1 presents the research strategy selected in this research to satisfy the objectives.

Table 1. Mapping of research strategy to the research objectives

Objectives	*Research strategy*
to explore the appropriateness of adapting EVM in the Spanish construction industry,	*Questionnaire survey*
to analyse the readiness of the firms, human resources and infrastructure (including legislation).	*Questionnaire survey, Interviews*
to recommend the most optimum but realistic way to adapt EVM in the contracting firms operating in the Spanish construction industry	*Interviews*

The questionnaire technique is defined as a general term including all techniques of data collection in which each respondent is asked to respond to the same set of questions in a predetermined order (deVaus, 1996). A self-administered postal questionnaire with space for feed back at the end has been designed for this research. The questions in the questionnaire were set to capture the state of art of project management implementation in the Spanish construction industry as well as to investigate the readiness of the Spanish construction companies to implement EVM in their practices. Follow up semi-structured interviews with senior project managers in the Spanish construction industry intend to further investigate the readiness of the firms, human resources and infrastructure aiming to identify potential barriers and enablers as well as potential scenarios of the most optimum but realistic way to adapt EVM in the contracting firms operating in the Spanish construction industry.

4.1. Sampling in Data Collection

In performing (questionnaire) surveys, the major concerns are typically the sample size, data collection procedures, analysis and measurement. However, the credibility of the respondents is also considered an important factor in this research. Due to the exploratory nature of the research without the intention of making generalisation at this stage, it was considered acceptable to implement purposive sampling. In case where the goal of the research is not to generalise but to obtain insights into a phenomenon, individuals, or events, then the researcher can purposefully selects individuals, groups, and settings that maximise understanding of the underlying phenomenon (Onwuegbuzie and Collins, 2007). The targeted respondents are project managers working in the Spanish construction industry for at least 5 years and have been involved in previous research conducted by the university. Geographically, these targeted respondents are based in Valencia and immediate surrounding areas but have been involved with construction projects in different regions of Spain. A majority of the targeted respondents are working for national and multinational construction companies in Spain. The number of the targeted respondents at the time of writing this paper is sixty project managers. The questionnaire were designed in English but translated into Spanish language prior to distribution for clarity and practical reasons.

Following a similar principle in targeting the respondents for interviews, fifteen senior project managers have also been targeted in this research. It has been reported that various mixed methods studies utilised some form of purposeful sampling, in which individuals, groups, and settings were considered for selection mainly to gain deeper understanding and richer information (Patton, 1990). The senior project managers targeted have been actively involved with managing construction projects in different regions of Spain for more than 10 years. The main intention of interviewing these senior project managers in this research project is to gain further understanding of the way construction companies operate in Spain to further determine their readiness and the most effective way to introduce and implement EVM, taking into account the operational and organisational factors. Depending on the respondents, the interviews were/will be conducted in English, Spanish and Valencian languages.

4.2. The Intended Data Analysis and Presentation of Findings

Statistical approaches that are utilised in the analytical survey approach necessitate the prior measurement of all pertinent variables for their inclusion in the questionnaire format (Ahlgren and Walberg, 1979). Due to the nature of the questions set in the questionnaire, it is intended to analyse and present the findings from the questionnaire of this research in a descriptive statistic manner supplemented by ranking analysis. The open ended part of the questionnaire is intended to provide a starting point for discussion in the follow up semi structured interviews to complement the list of potential areas to be discussed during the interviews. At the moment of preparing this paper, questionnaires have been distributed and received back with analysis on the way.

The resulting audio files recorded during the interviews are transcribed and the resulting transcripts are forwarded back to the interviewees for approval. Due to the multi-linguistic nature of the transcripts, the analyses are done by different members of the research team depending on their language proficiency. At the moment of writing this paper, the interviews, transcribing and analysis of the transcripts are taking place. Although the transcripts are in different languages, the analyses are conducted in English to maintain consistency. The analysis of the transcripts follows the main principles of analysing interview transcripts in Grounded Theory Methodology. Whilst it is not intended to adopt Grounded Theory Methodology as an overall methodology in this research, its techniques were utilised as a “surrogate” technique in analysing the textual data from interviews in this research. This was considered appropriate for this research as Grounded Theory Methodology provides a structured way of analysing the interview transcripts (Strauss and Corbin, 1998).

Following the analytical procedures of the Grounded Theory Methodology, interplay exists between analysis and data collection. Thus, in parallel with further data collection, development of the coding structure is taking place during the analysis. One option of establishing coding structure is by following the sequence of open coding, axial coding and selective coding (Heath and Cowley, 2004). Open coding involves organising the data into categories and sub-categories. Axial coding puts the data back together in a new way through establishing the relationships between these categories and sub-categories (Blaikie, 2000). Selective coding involves conceptualising the relationships among categories for theory building (Groat and Wang, 2002). Selective coding also includes comparing the potential theoretical frameworks emerging from analysis to the existing theories in the literature (Barrett and Stanley 1999).

When conducting research in construction, data was mainly provided by the stakeholders of the construction industry. Many of these investigations were aiming to identify any gaps followed by formulating recommendations for solutions. Thus, inevitably, these practitioners from the construction industry are part of the audience of the research findings, if not the most important audience of the study. However, previous study in the UK suggested that there is a problem for the construction industry practitioners to absorb and act directly upon the results of academic research (Gann, 2001) whilst the main route of dissemination of the findings is mainly facilitated through academic publications. Following the identification of practical needs of the construction industry audience for more holistic and concise format (Sutrisna and Abbott, 2007) and the success of presenting the outcome of research in a visual way using rich picture diagram to engage construction industry audience (Sutrisna and Barrett, 2007), this research intends to use rich picture diagram to present the findings.

A rich picture is defined as a cartoon-like representation that depicts the primary stakeholders, their interrelationship and their concerns (Monk and Howard, 1998). Rich pictures are generally constructed by interviewing people as an iterative process of understanding the problem and refining that understanding by the researcher, particularly on the early stages of the Soft System Methodology (for further discussion on Soft System Methodology refer to Checkland, 1981). This was found in line with the analytical procedures designed for this research which follows the main principles of the Grounded Theory Methodology. It has also been argued that by providing a macro view of the problem, the rich picture has improved the understanding and speed of comprehension by portraying the complexity of a problem and the entwined issues involved (Coyle and Alexander, 1997).

5. Conclusion and Further Research

Intending to provide advice to the Spanish construction industry and its practitioners in improving the management of construction projects in Spain, a research project has been set to investigate the potential of implementing Earned Value Management (EVM) in the Spanish construction industry. The methodology developed to satisfy the aim and objectives of the research project has been discussed in this paper. A mixed method, involving in-depth interviews with and distributing questioners to practitioners in the Spanish construction industry, has been described and mapped against the objectives of the research. The sampling procedures of the data collection as well as the characteristics of the targeted respondents have also been explained. Following this, the intended data analysis technique adapting analytical principles of the Grounded Theory Methodology was discussed leading to the intended presentation format of the outcome of the investigation using rich picture diagram. The use of rich picture diagram is expected to bridge the gap between academic research and construction industry audience by providing a more holistic but practical presentation of the findings.

At the moment of preparing this paper, data collection is on the way. Questionnaires have been distributed and received back from respondents leading to their ongoing analysis whilst the interviews and their analysis are conducted hand-in-hand with the practitioners. Further phase of the research includes completing the data collection and analysis before drawing conclusions and formulating recommendations for the implementation of EVM in the Spanish construction industry.

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Decreasing Opportunistic Behaviour through Appropriate Contracting Strategies in Construction Industries

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Abstract

Despite a rich literature in the context of construction industry on the contracting strategies, which stemmed from the long history of the industry and the strategic value of procurement, the industry is still accused of using inefficient contracting strategies. The purpose of this paper is to show how theoretical works on the choice of appropriate contracting strategies with an emphasis on decreasing opportunistic behaviour is based on different bodies of enquiry; the paper will highlight a lack of interaction between these normative works. To do this, the paper will critically review two of the prominent theories of the field including Transaction Cost Economics (TCE) theory and Economic-sociological theories. Both of these theories try to assist the clients to form the most appropriate contractual relations. In particular, both of these theories explore the causal relationships between the exchange features and appropriateness of contracting strategies. However, TCE theory and economic-sociological theories originated from two different bodies of enquiries (i.e. economics and sociology, respectively). Consequently, they highlighted the prominent notions of their original fields of knowledge without any interaction with other subject areas.

Keywords: Contracting Strategies, Construction Economics, Economic Sociology, Transaction Cost Economics, Opportunistic Behaviour

1. Introduction

The construction sector is adversely affected by opportunistic behaviour, claims, and disputes; costly governance processes and policing mechanisms derail the scarce project resources from delivering success. The rich literature on construction project management emphasises the role of clients in bringing success to the construction projects through forming appropriate contracting strategies (e.g. Smyth 2006; Ross 2005). Therefore, any normative academic work which helps the clients to decrease adversarial attitudes through more appropriate contractual regimes can lead to better allocation of scarce resources in the construction sector. Normative literature is used here to mean works which discuss how things should be.

The purpose of this paper is to show how literature on the choice of appropriate contracting strategies with an emphasis on the problem of non-cooperative behaviour, is based on different bodies of enquiry; the paper will highlight a lack of interaction between these normative theoretical works. To do this, the paper will critically review two of the prominent theories in the field including Transaction Cost Economics (TCE) theory and economic-sociological theories. Both of these theories try to assist the clients to form the most appropriate contractual relations. In particular, both of these theories explore the causal relationships between the exchange features and appropriateness of contracting strategies. However, TCE theory and economic-sociological theories originate from two different bodies of enquiry (i.e. economics and sociology, respectively). Consequently, they highlight the prominent notions within their original fields of knowledge without any interaction with other subject areas.

2. Contracting Strategies in Construction Industries

Before critically reviewing the theoretical works in relation to the choice of appropriate contracting strategies, it is worth discussing the spectrum of contracts and the importance of forming appropriate contractual relations by the clients within the early stages of the construction projects.

In construction industries, the client is the only party with motives and opportunity to bring success to the project (Smyth, 2006). Project process is carried out by a coalition of firms which are connected to each other through a “nexus of treaties” (Winch 2001). Clients can influence the project process through the interfaces they have with the project coalition. The shape of this nexus of treaties in Winch’s sense and the interfaces the client has with the project coalition are all largely formed at the early stages of the project through the procurement strategies. In construction industries, procurement could be broadly defined as the whole activities undertaken by the client to obtain a new building (Rowlinson, et al. 2000), meaning that procurement management covers a broad range of issues such as contract formulation, contractor selection, etc. One of the important stages in procurement is selecting an appropriate contracting strategy; this is the stage at which the client shapes the interface he has with the contractor (Winch 2001). All forms of contracts are intended to guarantee the parties’ objectives as much as possible. In fact, to prevent and cope with problems that might occur in future, the transaction could be governed by contracts (Buskens et al. 2003a, 2003b). According to Bower (2003), three main function areas of the contracts are as follows: work transfer, risk transfer and motive transfer. The contract functions are carried out through the contractual relations consisting of those which are explicitly contractual and those which are normative in all economic transactions. Thompson et al. (1998) classify the contractual relations as follows:

*.The relationship between parties
*.The responsibilities of each party
*.The risk allocated to each party
*.The reimbursement structure

Based on these interconnected contractual relations, there are different forms of contracts. Researchers categorise the contracts differently in order to provide frameworks which are appropriate for exploring different concepts; contracts are categorised based on the methods of payment (e.g.

Turner and Simister, 2001), the level of formality (e.g. Cox and Thompson, 1998), etc. However, generally, all forms of contracts could be located within a spectrum in which transactional fully documented contracts are on one side and fully relational contracts are at the other extreme (Williamson 2002; Cox 1996; Parker and Hartley 1997; Thompson et al. 1998). In other words, answering the make-or-buy dilemma in favour of buying, the client faces a spectrum of contracting strategies from the transactional (market) approach to the relational (co-operative) approach (Williamson 2002; Cox 1996).

2.1. Transactional (Market) Approach

Transactional approach in contracting strategies intends to exploit the market forces through providing competition between the potential contractors as much as possible (Ha°kansson and Jahre 2004; Parker and Hartley 1997). To create a competition, which leads to trimmed margins, the client needs to form an airtight contract which covers all the contingencies. Market-approach oriented literature in procurement management body of knowledge attempts to explore the issues matter in the tendering process.

The transactional approach is associated with the arm's-length relationship within which there is no considerable willingness from the client's side for the co-development of the project. In this approach, the principle is that if something- which has been contracted to be performed- goes wrong, a course of action in the form of negative incentives will be followed (Williamson, 1991). Therefore, Thompson et al. (1998) discussed that the market approach is evident in the contract through:

*. Provisions of liquidated damages for unsatisfactory performance
*.The use of performance bonds and retention monies
*. The use of rights to 'set-off'

Based on the transactional approach, risk sharing arrangements are not included in the contracting strategy and the whole risk is usually transferred to one party (usually the contractor). In terms of governance, within this context, contracts are interpreted very legalistically (Williamson, 1991). Therefore, in case of any disputes, more formal agreements supersede the less formal agreements, for example written agreements are chosen for dispute resolution even if the parties had verbally agreed upon some of the issues in another way. In extremely transactional approach oriented strategies, the issues between parties are entirely governed externally by national laws. While the extremely market-oriented approach may work well in markets within which client and supplier do not have any dependency to each other (Williamson, 1991), this approach may lead to some problems in the construction industry if it is implemented without careful consideration.

The problem attached to the transactional approach stems from contract incompleteness (Williamson, 1991). A contract is complete if it covers all the contingencies. In reality, contracts tend to be incomplete. In literature, bounded rationality and prohibitive costs of covering all foreseeable contingencies are known commonly as the reasons behind contract incompleteness (Hart and Moore, 1988). In addition, Spier (1992) showed that asymmetric information could lead to incomplete contracts as well. While bounded rationality inevitably makes all the contracts incomplete, prohibitive

costs of covering all known risks in a way that can be enforced and asymmetries in information may both lead the client to deliberately form an incomplete contract.
The problem of contract incompleteness with the market approach may lead to a vicious circle in which the client endlessly tries to form the contract which covers all the contingencies and to make sure that the contract is enforced (Winch 2000, 2001). On the other hand, in this situation, the contractor keeps looking for chances to remove the pressure on its margin through behaving opportunistically. Although eliminating opportunistic behaviour is one of the core aims of the clients in contract formation, the definition of opportunistic behaviour has remained implicit in the literature. However, it is usually associated with the situations in which the one party (here the contractor) behaves in a way that benefits him at the expense of the other party (here the client). For the contractor, the chances of opportunistic behaviour usually occur when there are project changes which are not covered by the contract. More intense competition and more controlling instruments could generate more motives for adversarial behaviour, which in turns lead to more detailed contracts- an endless cycle. Therefore, transactional approach could lead to projects with high costs of enforcement and costly process of contract formulation.

2.2. Relational Approach

While the transactional approach is on one extreme side of the contracting strategies spectrum, relational contracting (RC) is on the other side. RC is based on the understanding of mutual benefits and co-operative relationships (Rahman and Kumaraswamy, 2002). The concept of 'mutual benefits' means that contractors are motivated to meet clients' needs. It follows from this that it would be meaningless for a contractor to behave opportunistically. That is why RC is claimed to remove the vicious cycle which exists in the transactional approach (Winch, 2000). To create common objectives, sharing of gains and consequently losses are usually advised in the literature (e.g. Bennett and Jayes, 1998). This shows itself practically in incentive systems known as gainshare-painshare arrangements. Generally, positive incentives play an important role in RC (Williamson 1991; Thompson et al. 1998). Partnering, alliancing, joint venturing, and supply chain management are all various forms of relational contracting.

According to Williamson (1991), RC follows the 'elastic' forms of contract; in the extreme relational contracting the contract almost never accurately covers any contingencies, but it indicates the nature of the relationship between parties and the norms of dispute resolution if it materialises. This is in contrast with the transactional approach within which the contracts' conditions are endlessly refined. While in the transactional approach contract incompleteness is a problem, in RC, contracts are intended to be incomplete. The governance mode in RC is hybrid (Williamson, 1991) and could be bilateral or trilateral in which the third party is mobilised to arbitrate if disputes emerge, or a combination of both (Winch, 2006).The emphasis on the mode of governance arises from the idea of contract laws (plural) (Williamson, 2002). While traditional contracting literature implicitly assumes that there is a single law of contract which is enforced by courts, the literature on co-operative contracting highlights that each mode of governance is defined by a distinctive contract law regime (Williamson, 2002). In the context of RC, one of the important roles of the contract is to define the dispute resolution regime which is consistent with the co-operative spirit of the relationship.

While in the transactional approach context firms are connected to each other through contracts, in RC, it is more the relationship which connects parties firmly to each other (Pryke, 2001). That is why much work has been undertaken by researchers to investigate critical relationship features for relational contracts (e.g. Black et al. 2000). In most of these studies, trust is considered as the key relationship feature indicating a good basis for relational contracting (Black et al. 2000).
Although trust is usually known as a lubricant in governance of economic relations (Lui and Ngo, 2004; Williamson, 1991), there are challenging issues in considering trust itself as a governance mechanism (Adler, 2001). First of all, sometimes it is not as stable as other governance mechanisms. This is because of the empirical observations which show that trust is destroyed much easier than it can be conducted (Adler, 2001). In addition, if the trust as a governance mechanism does not work, the trustor will fail badly because trust governance makes betrayal more profitable for the trustee (Adler, 2001).

2.3. Any Cure-all Contracting Strategies? The Notions of Appropriateness in Contracting

After a tide of literature in support of relational contracting, concerns have been raised by some researchers about the danger of the out-of-context use of RC (Parker and Hartley, 1997; Cox 2004, 1996); it is expressed that the relational approach cannot be a 'cure-all' contracting arrangement. Researchers, who expressed doubts about the prescriptive outcomes of studies undertaken in the context of RC, criticise the research methods common in works done in the context of relational contracting (Cox, 1996; Parker and Hartley, 1997). Parker and Hartley (1997) highlighted a lack of supporting theoretical consideration in studies which recommend RC as competence in procurement. This is consistent with Cox (1996). In addition, Cox (1996) highlights the danger of anecdotal evidence in prescriptive literature in the field of contracting strategy.

Cox (2004) emphasises the notion of 'appropriateness' in contracting strategy and attracts the attention of buying organisations to the fact that their ultimate aim is to procure the projects with minimum total cost rather than using a particular contracting strategy. Williamson (2002) highlights the position of the 'science of contracting' which "entails efforts by the immediate parties to a transaction to align incentives and to craft governance structures that are better attuned to their exchange needs". He places emphasis on the science of contracting in solving the problem of 'order' in the private sector.

The costs attached to any of the contracting strategies are different and variable based on the project's features, market conditions, client's organisational culture, client's requirements, etc (Bower, 2003); this is because of different incentives and governance mechanism inherent in each contracting strategy (Williamson, 2002). The contracting strategy which leads to the minimum total costs would be the most appropriate way of contracting. While in the transactional approach the client needs to be prepared for costly dispute resolution processes and costs of writing fully documented contracts, in the context of RC the client needs to take some risks in the project, play an active role in generating trust, pay for negotiation costs, etc (Ha°kansson and Jahre 2004).

3. Transaction Cost Economics Theory

Transaction Cost Economics (TCE) theory assists the clients to form appropriate contractual relations. TCE theory originates from economics. Economics is focused on one's reasons and the application of these reasons to the problem of allocation of limited resources to unlimited needs (Simon, 1979). TCE theory considers the choice of appropriate contracting strategy from the perspective of allocating scarce resources in construction (i.e. construction economics). In construction projects, resources are used for the production costs and transaction costs (TC). TCE theory relies on the comparison of transaction costs in different forms of contractual relationships. Transaction Cost was first introduced by Williamson to show the costs attached to each transaction except for the production costs. While at first he was vague in defining the TC and described them as "equivalent to friction in a physical system" (Ross, 2005), in his later works (e.g. Williamson, 2002) Williamson defines transaction costs as "the costs of running the economic system". Hodgson (1993) categorises the costs of transacting into three groups including 'Search and information costs', 'Bargaining and decision costs', and 'Policing and enforcement costs'. Therefore, the minimum transaction cost for each project originates from the optimum combination of 'Search and Information Costs', 'Bargaining and Decision Costs', and 'Policing and Enforcement Costs'. TCE theory helps the clients to form contracting strategies which lead to the minimum transaction costs in the projects.

TCE theory explores the correlation between contingency factors and behavioural factors. Contingency factors are the key dimensions of transaction (project) that have important ramifications for governance. These factors include asset specificity, uncertainty, and frequency of the transaction. Behavioural factors are about the ways in which agents respond to contingency factors; bounded Rationality, learning and opportunistic behaviour are human reflections towards respectively uncertainty, frequency and asset specificity Williamson, 2002, 1996).

Before discussing this correlation, it may be worth reviewing the concepts of asset specificity and bounded rationality. Asset specificity relates to the investments done specifically for the transaction. These specialised investments may be in the form of physical assets, specialised human assets, site specificity, dedicated assets, or brand-name capital (Williamson 2002). In projects with high levels of asset specificity the continuity of the exchange relationship may have significant cost consequences (Williamson 2002, 1991).
Bounded rationality refers to limited rate and storage capacity of individuals for processing data without error (Williamson, 1973). Therefore, it is about the human feature by which the behaviour is intentionally rational but only partially so (Williamson 2002, 1991).

Fig.1 shows the relationship between the contingency factors and the behavioural factors.

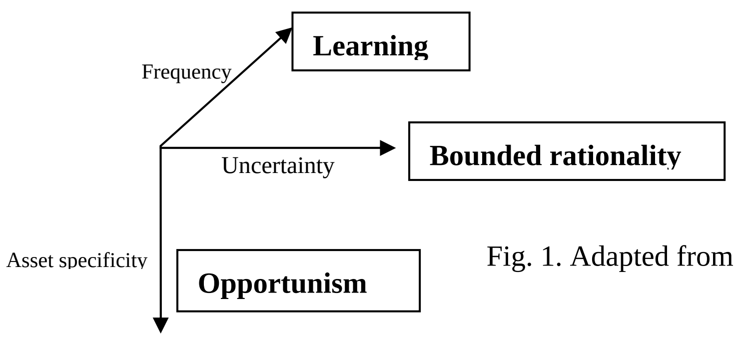

Fig. 1. Adapted from Winch, 2001

In construction projects, agents deal with high levels of uncertainty at early stages of the project. Human behaviour towards uncertainty is bounded rationality. As can be seen in Fig. 1, due to bounded rationality, which makes the contracts inevitably incomplete, in projects with high levels of uncertainties, unforeseeable contingencies may materialise. In these situations, re-negotiation is required. However, the contractor could behave opportunistically during the re-negotiation process if the new situation had not been contracted to be performed. The client is exposed to the opportunistic costs due to the asset specificity which the supplier holds. In construction, most of the asset specificity is post-contract. Asset specificity brings power for the party (usually the contractor) who holds it (Cox et al., 2002) and exposes the other party (usually the client) to the costs of adversarial behaviour up to the threshold of switching costs (Winch, 2001). Agents learn from frequent transactions. However, in the construction sector each project is to a large extent unique (Fig.1).

Under high levels of uncertainty and high levels of asset specificity, TCE theory suggests that to avoid opportunistic behaviour, clients need to choose contracting arrangements which are more co-operative (relational approach). In fact, when there are high levels of uncertainty and asset specificity, the transactional approach may lead to high cost consequences. Therefore, the TCE suggests placing emphasis on the effectiveness and flexibility rather than efficiency (Winch, 2006).
Based on the TCE framework, if the client can eliminate uncertainty or asset specificity, then there is no harm in transactional contracting and it is possible to only focus on efficiency; when there is no uncertainty, it is possible to write a contract which covers all the contingencies. So, the customer will not need any re-negotiation during the project process and consequently the buyer will not be exposed to any adversarial behaviour. This does not happen in the real world; in real the world actors are always dealing with some level of uncertainty. That is why the client always needs to make a balance between the costs associated with the contingency factors and the efficiency which could be gained from competition. In addition, considering that low levels of asset specificity means that the client can replace the contractor with incurring only negligible costs (Williamson, 1991), in cases that the post contract’s specificity is not considerable, the client could be sure that the costs of contractor opportunistic behaviour is insignificant.

In the TCE framework, the most important contingency factors are related to the project itself; TCE does not emphasise the nature of the client-contractor relationship in its analysis. TCE places all the emphasis on the transaction features, as if the transaction occurs between anonymous clients and contractors in pure spot markets. This view of the buyer-supplier relation originates from economics (Williamson, 1991). The premise behind this view is that the behaviour of agents in any economic relationship is directed by their explicit goals, and the economic actors make decisions independently from their social connections (Weintraub, 1993).

4. Economic-Sociological Perspectives on governance of economic transactions

According to Batenburg et al. (2003) and Swedberg (1997), the subject area of new economic-sociology was consolidated by Gronovetter work in 1985 entitled “Economic Action and Social Structure: The Problem of Embeddedness”. In his well-cited paper, Granovetter (1985) emphasised the role of social relations in governance costs. He introduced the notion of embeddedness which is about the degree to which individuals or firms are involved in a social network (Granovetter, 1985). The economic sociological perspective points out that the contractual behaviour of firms depends not only on transaction characteristics but also on previous and expected future contacts between the supplier and the buyers (Batenburg et al. 2003). Therefore, to form the most appropriate contractual relation, the clients need to consider how embedded they are.

The notion of embeddedness is about the ties and contacts between the client and the contractor as well as their ties and relations with third parties (Batenburg et al. 2003). ‘Dyadic embeddedness’ is about the extent to which the same buyer and supplier are involved with each other over time (Buskens et al. 2003b). Dyadic embeddedness is either about the past experiences or the expected future experiences. Another kind of embeddedness is called ‘network embeddedness’ which is about the extent to which the two parties are embedded in the network of third parties (Buskens et al. 2003b).

Embeddedness influences the governance costs through two mechanisms of ‘learning’ and ‘control’. Learning refers to the possibility for the actors to gain information through previous similar interactions. The client can gain information through previous experiences with the contractor (dyadic embeddedness) or the client may be able to gain some information about the trustworthiness of the contractor through those who have had similar interactions with the contractor (network embeddedness) (Buskens and Raub, 2002). Positive experiences or negative information achieved through past experiences could lead to the emergence of trust or distrust (Buskens and Raub, 2002; Buskens et al. 2003b).

The second mechanism through which embeddedness affects trust is ‘control’. Control mechanism is about the sanction power of the client and its network. The fact that the contractor takes into account the sanction threat from the buyer as well as the buyer’s network in each transaction leads to some sort of power for the client. This threat works as an incentive for honouring trust (Buskens and Raub, 2002). Therefore, the stronger the opportunities for the buyer to sanction the contractor through his network, the stronger incentives the contractor has to honour trust and the stronger reasons the client has to place the exchange relationship based on trust and relational contracting (Buskens et al. 2003b). Depending on the nature of the exchange relationship, learning, control mechanism or both of them may be crucial.

Both economists and sociologists acknowledge that the trustworthiness of a contractor is not easily observable prior to a transaction (Buskens et al. 2003b). However, the reaction of the scholars towards this ambiguity is different. In the context of Williamson’s approach, in exchange relationships with low levels of frequency, it is too difficult for the buyer to make sure that the supplier is not intending to behave opportunistically. Consequently, through Williamson’s perspectives, the governance structure is the contractual framework within which the transaction is located (Kammann et al. 2006). In fact, in the absence of trust, market co-ordination takes the form of spot markets (Adler, 2001). On the other hand, scholars who are influenced by the sociological theories claim that non-contractual relations play an important governance role in economic exchange relations. This difference in perspectives has partly arisen from fundamental contrasts in the conceptions of ‘actor’ between sociologists and economists. Economists hold the view that economic actors make decisions independently from each other and from the social relations they have, but the sociologists assume that actors are socially constructed entities (Smelser and Swedberg, 1994). Considering the fundamental contrasts between the assumptions of subject areas from which the theories of appropriate contracting strategies originated, it is not surprising if these theories lead to different or conflicting guidelines. Therefore, the remaining question would be about the co-existence between these theories. Is it possible for the clients to take advantage of both of these theories? Is it possible to provide the clients with guidelines in which the achievements of both theories are counted? In the context of construction management, little research has been done to link normative theoretical works to each other in pursuit of more detailed signposts for clients wishing to decrease the opportunistic behaviour through more appropriate contractual relations.

5. Conclusion

Clients can do their own bit in bringing success to the construction projects by forming appropriate contracting strategies. Consequently, theoretical works which explore the causal relationships between project characteristics and the costs associated to each contracting strategy could play an important role in project success.

The paper reviewed two of the prominent works concerned with the choice of appropriate contractual relations, and a lack of interaction between these theories in relation with decreasing the non-cooperative behaviour has been highlighted. The paper proposes that these theories may co-exist. In other words, the paper proposes a pragmatic approach to the problem of non-cooperative behaviour between contractors and clients in construction industries. The pragmatic approach will help the researchers to consider the socially constructed notions as well as the positivist works. Consideration of different perspectives about the contractual relations could potentially lead to the emergence of more detailed normative works which will help the clients to reflect upon the projects' characteristics more efficiently.

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Indicators of a Flawless Construction Process

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Abstract

This paper is reviewing an ongoing research project which has two central aims. Firstly, to identify and analyse indicators of central importance to a successful construction process in the perspective of handing-over flawless buildings to clients. Secondly, from this knowledge, to deduce methods of best-practice in order to reduce the level of defects in construction projects.

The research draws upon statistics from The Benchmark Centre for the Danish Construction Sector (BEC). BEC has been collecting data on the number and character of defects (legally defined) in connection with buildings at hand-over to clients since 2004. Furthermore, research data is based on an electronic questionnaire filled in by clients and contractors as a retrospective analysis of the management conditions in construction projects resulting in either none or many defects at hand-over to the client. A total of 130 responded to the questionnaire.

Processing of data and information from questionnaires has been carried out using different statistical and analytical methods. Focus has been on the number and graduation of seriousness of defects, on type of tender and organization of the construction process, on the type of client and on budgetary issues. The qualitative analysis focused on management of budget, time, quality, collaboration and coordination, competences and skills, safety and risk, and on the complexity of the construction projects.

The results of the analysis are showing statistically significant differences for those construction processes characterized by few or no defects compared to those with many serious defects. The planning of budgetary conditions, time schedules, and an early and continuous defects control proved to have the most significant influence on the final results related to defects in the building at hand-over to the client. Furthermore, also quality control, the collaboration between parties, skills and safety initiatives are influencing factors in the analysis of results.

Keywords: Construction Defects, Flawless Construction, Management, The Delivery Process

1. Introduction

This paper presents a number of results from an ongoing research into construction processes focusing on factors influencing the occurrence of defects at hand-over of completed buildings to the client.The research project comprises of an analysis of two sets of data on construction. One originates from The Benchmark Centre for the Danish Construction Sector (BEC-data). It contains data on evaluations of completed buildings throughout the period 2007-10. The other data set represents a questionnaire survey (SPSK data) among contractors and clients being asked specifically on the conditions characterizing the construction of the buildings which had been subject to BEC evaluations.The purpose of analyzing these data is to investigate whether different characteristics can be identified when comparing buildings with many defects at hand-over versus buildings with few such. And if so to specify the nature of these different characteristics on construction project and contract level.

2. Theory

Building research within this field shows many different causes of defects and general discrepancies which can be localized throughout the whole value chain of construction project. Some references have sought to categorize some of the most important types of causes in relation to both actors and processes (Jørgensen 2009). Explanations of causes related to the involved actors' attitudes and actions are characterized by 1: lack of communication and coordination (Josephson 1994, Apelgren et al. 2005, Nielsen et al. 2004), 2: lack of knowledge and experience (Josephson 1994, Nielsen et al. 2004), and 3: engagement, stress and time pressure (Josephson 1994, Nielsen et al. 2004). Other sources, however, emphasize problems with defective project information, defects in building products, poor planning, and poor execution of work (Nielsen 2004). Explanations of causes related to building processes include deficiencies in the client's project brief, when defining the concept, the quality level, and functional demands for the project. Thus the client's strategy in relation to quality level, and the relationship between the level of ambition and the resources for technically ensuring the construction quality are some of the critical elements typically involved (Henriksen & Hansen 2006). But also deficiencies and errors in the project design - and defects in deliverances from supplies, deficient planning of execution of the work, contractors' poor management and organization of work, and scanty management of delays and operations' flow are perpetually referred to in literature (Josephson 1994, Nielsen et al. 2004, Apelgren et al. 2005). Case stories on building processes are outlining a rather clear picture of the complexity of construction projects, thus indicating how seemingly insignificant factors and different understanding of situations can often lead to unfortunate and undesirable consequences (Kreiner 2005, Jørgensen 2009). It has therefore been considered appropriate in the theory review below to examine these areas of problems within the construction process which have been selected as crucial by different researchers. Subsequently, the analytical aim of this research project has been to establish an empirical outset for identifying such problems as objective indicators on the outcome of production processes as measured by defects. For instance, research shows that an important prerequisite for being able to estimate costs in the initial phases of a construction projects is related to knowledge on potential and possible solutions, on the cost of these and on how fast they can be realized (Winch 2010). An ongoing and accurate cost management in construction projects is consequently essential for a successful result (Chapman et al. 2010). It is only too well known that budget and time schedules are playing a central role in building processes, where insufficient financial resources and management lead to the problems as listed above, while insufficient time frames results in forced building operations which in particular are causing pressure and poor workmanship during the last phases of the process. Further relevant factors regarding economy are the use of incentives and bonuses in order to reward firms or actors for efficient deliveries and work. Experiences with open project economy with firms sharing their internal accounts have also proved to create greater trust between the parties involved in the project. This principle is for example applied in partnering projects as a method to improve the quality of design information and decision making. Some of the traditional problems related to flaws in the building process are 1: that the client often chooses to aim at the lowest price; 2: that the client's requirements on the construction project are not sufficiently precise; 3: that there is little focus on the business aspects of the case; and 4: that competition at tender often leads to underbidding. Such issues are resulting in defective project planning and implementation, poor buildability, inexact specifications, and resistance toward using experts and towards finding weaknesses and areas of risk. If these are furthermore amplified by lack of planning and management skills, then surely the project success will fail to appear (Winch 2010). However, a clear division of responsibilities can minimize the risk and effect of unexpected occurrences (Szentes 2010) - and also help the actors to optimizing their own main tasks. It is therefore important that the project has a well-functioning project management group with clear goals and agendas (Szentes 2010). Exactly because construction projects have many different stakeholders and actors, increasing difficulties will occur if in particular the management and organization are not robust towards handling such problems as tortuous paths of communication, lack of mutual understanding, unpredictable building site conditions, opaque frameworks for the quality of the work done, and incomplete deliveries by suppliers (Loushine 2006). Therefore, good reasons to focus on coordination, communication and cooperation remain crucial. Deficient design and integration of quality in the building process is inversely creating a general lack of focus on quality and customer value, poor contracts, and absent understanding of the general difficulties related to carrying out construction projects (Leong & Tilley 2008). This points to the question forms of collaboration and culture, also including the team awareness of the quality expected by the client. The project manager's style of leadership as concerns commitment and involvement are central factors (Yang et al. 2010, Misumi 1985). So is his ability to develop coherence and realistic plans (Chua et al. 1999, Winch 2010), since well-functioning planning practices are of central importance to realizing the construction project. However, because not all detailed aspects of a construction project can ever be planned, also the manager's capability in dynamic problem solving is crucial (Winch 2010, Thuesen 2006). It is well known that a central element in planning practices implies the use of concepts, methods and tools which can optimize the project's overall design aspects in the perspective of balancing quality, economy and time. Having transformed such main decisions into specific plans (budget, schedules, QC etc.), the ongoing management and follow-up upon these plans is essential (Winch 2010, Szentes 2010). This entails continued monitoring of the project's current status in order to identify discrepancies in relation to planned performance (Szentes 2010). During this process the management's attention towards quality issues will of course be depending of precisely the explicitly – but also implicitly - expressed requirements on the level of quality and quality control, time and resource planning, monitoring and control of deliveries etc. (Jørgensen 2009). Thus the management style and behavior is due to vary from project to project in accordance with influencing factors of external nature. As mentioned collaborative processes are of central importance to the output of activities in construction (Winch 2010, Szentes 2010). An important aspect of the collaborative effort is the ability of the project organisation to formulate common goals and to continuously follow up upon these, as seen for example in partnering projects. A long list of means and tools can be applied to raise the level of trust and collaborative atmosphere, like team-building, open accounts, conflict management, celebration of achieved project successes etc. (Szentes 2010). Organizational access to appropriate competences is important for the project’s success. Lacking competences at designers as well as at contractors are due to be causing defects in construction projects (BEC 2008). Also project management competences in particular are seen to be a critical success factor (Szentes 2010). These include the capability of facilitating open communication and collaboration in the process of formulating common goals, as mentioned above. So one of the central, ad often neglected challenges in resource allocation and planning is the ability to attract and maintain a qualified personnel and workforce during the project phases (Chapman et al. 2010). As aspects of qualifications/competences experience and skills are of central importance in construction. Experience is embedded in individuals (Thuesen 2006), and it is necessary to differentiate between for instance general experience, experience from similar projects, and mutual knowledge in social relations. Thus competences and experiences are equally important in choosing partners for a project (Hardeman & Vlist 2010) - but unfortunately such parameters are rarely given priority when confronted with the lowest price. Finally, new technology and innovation have great significance in project design and execution (Wadugodapitiya et al. 2010, Chapman et al. 2010). In the perspective of management innovation, the working climate is heavily influencing performance (Wadugodapitiya et al. 2010), including such factors as employee satisfaction, working hours and stress conditions, absence due to illness, and the overall working environment. These issues have direct and indirect implications on the quality culture in projects. A relevant source of knowledge and inspiration regarding the effect of quality culture is represented in the databases of the Construction Industry Institute (CII), Texas University which is performing continued benchmarking surveys on large American construction projects. According to CII, beneficial quality culture can be indentified from the use of planning and management concepts and tools such as lean construction, partnering, TQM, SCM, team building, collaboration, quality control systems and requirements, and safety work. CII also finds that the characteristics of quality culture can be associated with competences which point to a quality determined choice of partners, whether foreign labor is used, and for instance such basic conditions as accessibility, waste management and clean up standards. Knowledge sharing, trust and involvement of craftsmen also show up to be crucial. The numerous perspectives and sources reviewed above will be addressed thematically in the analytical approach of the research project. Particularly, they will be framed into the empirical part of the research.

3. Research methods

The Benchmark Centre for the Danish Construction Sector (BEC) is a business foundation established by a broad circle of actors from the construction sector in order to promote quality and efficiency. The Center’s function is to collect and organize information and evaluations from the parties involved in construction projects. The collected data is used to calculate key performance indicators. The type of defects, deficiencies and failures registered in BEC are defined as legal events, i.e. discrepancies registered by the client by hand-over, thus expressing some sort of lacking conformance between what has been delivered and what was agreed upon by the customer and the supplier (the client and the contractor). BEC calculates defects as the number of concrete defects and not as technical types of defects. Defects are classified into three categories:

- A0, cosmetic defects, i.e. defects with no or insignificant technical consequence to construction.
- A1, less serious defects, i.e. defects with little technical construction significance; defects without influence on the construction - or affecting the function of parts of the construction project.
- A2, serious or critical defects, i.e. defects with some or great technical construction significance; defects that affect the construction or the function of parts of the construction project.

An extract from BEC's data base on reported defects per DKK 1 mill. contracted project budget is showing an average occurrence of number of defects distributed among the above three categories of seriousness in the relationship 1:5:50. This relationship is then applied for a statistical weighting of defects in the individual construction project, thus making it possible to sum up a numerical value suitable for comparing across projects, as the value 15 represents the average construction project (Jørgensen 2010). On this basis the evaluated construction projects have been shaped into three 'quality groups':

- Quality group A contains the construction projects delivered with none or few cosmetic defects
- Quality group B contains the projects delivered with typical defects on average level
- Quality group C contains the projects delivered with many and serious defects

	Quality group		
329 construction projects	A	B	C
Cosmetic failure	0,97	6,45	14,6
Typical failure	0,06	0,98	5,96
Critical failure	0	0,04	0,49

Figure 1: Illustrates the distribution of the 329 construction projects, evaluated by BEC, located in three quality groups and indicating the three types of defects and their degree of seriousness. The figure shows the average number of defects per 1 mill. contract sum in the construction projects located within each of the three quality groups.

The BEC dataset comprises of 329 construction projects and 621 contracts. 51 % of these are located in quality group A; 34 % in quality group B and 15 % in quality group C. Further to these data a questionnaire of 90 questions was then composed, covering the themes shown in table 1.

The questionnaires were deployed to clients as well as contractors – and responses were subsequently linked to information already present in the BEC data set. Responses were collected from 67 clients and 130 contractors. Later it showed most relevant to analyze closer responses from contractors. The representatively of responses from contractors in the three quality groups is 56% in A, 29% in B, and 15% in C. This distribution is close to average (as indicated above). The actual analysis was divided into three. Initially a univariate analysis of all information in the BEC data set plus responses from the questionnaire was carried out – focusing on statistical disparities between the three quality groups. Then on the basis of this analysis the 90 questions were divided into themes, broadly corresponding to table 1 thematically, and a new univariate analysis was carried out in order to identify a distinction between respondents with a very positive attitude in answering, against those answering negatively to the generally positively expressed questions. The third type of analysis is then consisting of an exposure of links using correlation and multivariate methods in order to create profiles of the 'good and the bad' respectively.

Table 1:Themes for the questionnaire

Economy	BEC´s data on economy are supplemented with: • Budgetary Planning • Cost management • Consequences of budget • Incentives and bonuses
Construction schedules	BEC´s data on construction schedules and deadlines etc. are supplemented with: • Construction schedule requirements • Time scheduling and time consumption • Time consumption for project phases
Value and priorities	• Project priorities • Basis for selecting partners
Quality	• Planning quality • Producing quality • Quality result
Competences	• Management skills • Survey of the parties' skills
Collaboration	• Collaboration climate • Collaboration forms and agreements • Involvement across the parties • Methods for strengthening collaboration
Coordination and planning	• Managing project changes • Meetings and meeting structure • Planning methods • Production process
Working environment	• Safety work implementation • Safety conditions on the building site
Risks, complexity and innovation	• Construction project complexity • Innovative methods • Important risks

4. Results

The analyses have been carried out for the 130 contractors exclusively who have responded to the questionnaire. Responses from the 67 clients have not been made subject to analytical efforts, the argument being their limited number and a very small differentiation with a general attitude in the most positive end of the scale. This may indicate that either only the most satisfied clients responded – or alternatively: clients did not find themselves capable of responding to questions on a detailed level about concrete conditions and problems in the construction processes. However, BEC´s own measures of clients' satisfaction shows a clear correlation between high versus less high satisfaction with the construction process in relation to the range and seriousness of defects when comparing quality groups A and C. The analyses of contractors' responses are showing generally largest differences between quality groups A and C, while values for quality group B are fluctuating between the two extremities. Therefore, a major analytical effort will be concentrating on the differences between quality groups A and C. Thus the univariate analytical approach is indicating the following two issues to be representing the strongest differences of statistical significance between quality groups A and C:

1. Cost management
2. Early and continuous management of defects

There is much evidence that these two issues have major influence on the occurrence of defects at hand over. Looking at the specific questions the following questions are showing statistical significance when relating quality group A and C:

- Cost management:
    - The budgetary framework has an influence on construction quality, particularly when budget and demands on quality are conforming.
    - There is good conformance between the result delivered and the construction costs.
    - It is of importance that clients are capable of setting objectives for the overalll cost management.
    - It is of importance that designers are capable of making reasonable design solutions in relation to budget and resources.
- Schedule management:
    - The time schedule and the demands on quality level showed to be in good conformance.
- Defect management:
    - Considering handling of defects this is typically dealt with during the process of construction, however, more often in quality group A the construction is specifically reviewed for defects and these are rectified before hand over.
- Execution of quality management:
    - Contractors in quality group A are more critical towards the quality of project specifications, the contractual basis and the brief as concerns quality management than contractors in quality group C. This is supported by the fact that group A contractors more often carry out quality review on project specifications prior to construction, just as clients in group A have a more explicit notion of contractors'

respect towards their demands on quality (however this statement cannot be demonstrated with statistical significance.
    - Furthermore, quality group A responds more positively to questions concerning preparation of adequate plans for supervision and control, appropriate handling of interfaces between trades – and reasonable control of own work (again, statistical significance has not been achieved).
- Management skills:
    - Evaluations of competences are generally scoring high. However, group A actors' capabilities are on a higher level than those of group C. (statistical significance has not been achieved).
- Collaboration in relation to cost, time and quality:
    - Quality group A is giving higher priority to balancing costs, time schedules and plans for quality control as collaborative, open and joint solutions (statistical significance has not been achieved).
- Health and safety management:
    - Considering management of the working environment the responses from quality group A score higher compared to group C, in particular concerning planning of safety during the design and production stage, and also concerning waste disposal, neatness and tidily conditions on site.

Furthermore, analyses have been focusing on forms of contracts in relation to project size and total costs. Contracts have been divided into D&B contracts, main contracts and trade contracts. Responses differentiate most when comparing D&B projects with trade contract projects. Generally, responses from the first type of contracts score higher than those related to the other types. In 58 out of 65 questions D&B projects score higher than trade contract projects, and in 36 of these questions the difference is statistically significant. When looking at differences between the quality groups A and C in relation to contractual forms, a larger variation can be observed within D&B projects while the variety is less pronounced within trade contract projects. Differences between quality groups A and C in D&B projects are statistically significant as concerns these questionnaire themes:

- Cost management
- Scheduling
- Early and continuous management of defects

Furthermore, a certain difference can be observed concerning the questionnaire themes 'Budget consequences', 'Time frames for design and review', 'Management skills', 'Workforce skills', 'Collaboration in costing, scheduling and quality', and in 'Mutual acquaintance'. Differences between quality groups A and C in trade contract projects are statistically significant as concerns these questionnaire themes:

- Managing the quality system
- Skills of construction workers

Responses to the other questionnaire themes are characterized by minor differences between quality groups A and C. Moreover, D&B projects stand out remarkably because of using new concepts of collaboration and management, more involving of production trades in the design process, larger planning efforts in relation to meetings, supplies, processes etc, and because of implementing ‘safety-audit sites’ and safety instructions. Thus D&B projects for instance apply methods associated with partnering and lean construction. In trade contract projects contractors have more difficulties in planning and managing costs and schedules; only to a lesser extent they carry out continuing defect reviews and they have difficulties in creating a good working climate. As earlier mentioned BEC is collecting information on construction projects on the overall level as well as on the individual contract level, relating to the total project budget and to the budget of the single contracts. In this research the size of projects has been divided into three budget groups: below DKK 5 mill., between DKK 5-25 mill., and larger than DKK 25 mill. Looking at the project budget statistically significant differences appear between quality group A and C, particularly for projects budgets beyond DKK 25 mill. Concerning small projects below DKK 5 mill. the results are showing statistically significant differences in contracts in quality group A and in C in relation to the following questionnaire statements:

- The client was qualified at determining the overall planning of costs and resources.
- The design team was qualified at making reasonable solutions in relation to costs and resources.
- There was no need for the client to withhold payment rates at hand over.
- The client’s demands on the craftsman quality appeared clearly from the project specifications/brief.
- The client’s demands on quality management in the construction process appeared clearly from the contractual set up.
- The client’s quality demands were regarded during production.
- The contractor’s own quality control was expedient
- The contractor knew suppliers/the other contractors from previous projects.
- The solutions to complex construction areas were well managed (applying for instance lists of obstacles)
- The construction process was well managed (applying for instance PPC (Percent Planned Completed) measuring)
- Social events, beneficial for collaboration, were held.

For large construction projects (above 25 mill.) the results demonstrate statistical significant differences between contracts in quality group A and C within the following questionnaire themes:

- There was a good conformance between the delivered result and the construction costs.
- Openness between partners on economy issues was experienced (like in Partnering).
- There was no need for the client to withhold payment rates at hand over.
- The contractor felt no need to issue additional charges during the project.
- The time schedule and the demands on quality level in the project was in good conformance.
- Sufficient time for reviewing the project for securing of constructability and craftsman quality was av ailable.
- The contractor carried out defects review and rectification before hand over to the client.
- The contractor carried out a defects review together with the client at pre-hand over, and had defects rectified before final hand over.

- The client's demands on quality were regarded during production.
- The contractor assumes the craftsmen to generally have had the appropriate craftsman skills for filling out the job requirements.
- The project managers of both client and D&B contractor showed commitment, involvement and supporting collaborative attitude towards the different parties.
- The project parties jointly determined the appropriate costs, schedules, targets and sub-targets
- During the design process appropriate attention was paid to safety issues.
- The high complexity of the project made high demands on the innovative capabilities of the constractor.
- Teambuilding events with a positive influence on collaboration were held.
- The contractor employed financial incentives in order to comply with budgetary frameworks.

By grouping the questions into 30 thematic groups, data demonstrate significant differences for the large construction projects in relation to the question groups on budgetary planning, implementation of early and continuous defects review, craftsmen's skills, and collaboration on prioritizing and solutions. For small projects, however, significant differences concern budgetary planning and cost consequences. In the multivariate analysis a profile was sought for in order to illustrate the way in which quality group A differentiate positively from quality group C. This applies to the following themes: 'Budgetary planning', 'Cost consequences', 'Time scheduling', 'Time for design/review/production', 'Planning of quality, 'Early and continuous defects review', 'Execution of quality management', 'Management skills', 'Craftmen's skills', 'Collaborative climate', 'Collaboration in relation to budget, time and quality', 'Mutual previous acquaintance', 'Safety management', Contractors' competences', 'Applied concepts of collaboration', 'Engaging partners', 'Initiatives on collaboration', 'Applied lean meetings' and 'Safety procedures'.

5. Findings

As expected the analysis is demonstrating a vast number of factors to be of importance to completing a building without defects. It may also be considered trivial that good budgetary planning and continuous defect review processes have a major impact on the achieving a successful result. More interesting maybe is the observation of differences between a.o. D&B contracts and trade contracts. The research is showing good as well as poor results in both cases – however, much also indicates that it is somewhat easier to achieve good results within D&B projects. Furthermore, the division of project size on the basis of budget sum is showing rather big differences in the performance conditions when comparing larger projects above DKK 25 mill. with smaller projects below DKK 5 mill. Large construction projects are analytically characteristic by applying new management concepts, and they appear to be more capable at planning and management, which again is proving important for handing over the building with none or few cosmetic defects. Accordingly, those large construction projects not capable of providing decent planning and management, also deliver projects with many defects of serious categories. It is looking differently for smaller construction projects where capabilities of applying different planning and management methods are more vague – and where other factors may have determining influence on whether the project is finalized with none or few defects. One hypothesis could point to the dependence on individual random competences, because dedicated management resources are often only to a limited degree allocated in small projects.

6. Discussion

The empirical data sets of this research are solely representing construction projects which have been evaluated by BEC. These account for only a smaller share of the total number of projects carried out in Denmark. Furthermore the response ratio to the questionnaire part is as low as 22%. It may therefore be discussed whether data is representative for Danish construction in general. Questions have been addressed to both clients and project managers in charge on contracts, as these were both acting as contact persons in the BEC evaluations. But it may be questioned whether these actors were best suited to respond to the type of questions specifically focused on the construction process, collaboration and coordination etc. There are some indications pointing towards contractors as being better informed than clients to giving detailed and differentiated answers to questions. Certainly, the importance of new management concepts, new process developments, implementation of ICTs and new building materials etc. may be underexposed - for the reason alone being that projects included in the analytical research did not apply such means to any particular extent. Finally, it may be discussed if the number of defects at hand over is a true and fair indication to whether the construction project has been successful in delivering value to the client and customer? When BEC has chosen to evaluate the proportions of defects at hand over it was from the beginning mainly due to a government policy aiming at reducing the problem of defects. In addition to this defect data had the practical advantage as a benchmark because such data already exist in construction projects, meaning that no further administrative burdens had to be inflicted on construction clients and firms. In relation to this methodological reservation, however, also questions on how different types of defects should weight reciprocally in seriousness scaling – and whether the weighting applied in this research is appropriate – should be discussed. The obvious correlation between clients' measure of satisfaction, and the categorizing of contracts in quality group A, B and C is telling in favor of defects as an excellent indicator, in particular when and if they are given mutual weight. But this fact is to a high degree depending upon the criteria defined by the client for his construction project, and upon the client's expectations on the quality of the commissioned building. There might also be a tendency in evaluations of customer satisfaction (in parallel to evaluation of defects) to generate information more on the finishing stage and completion of the construction project than on the process as a whole. Thus, it is well known that customer satisfaction is easily influenced negatively when only minor problems occur at take-over – and still the whole process of procuring and delivery may have been in perfect order.

7. Conclusion

The research results which have been reviewed in this paper provide us with important information about circumstances and factors of central importance to the flawless construction process. However, the investigation does not include specific knowledge on how to actually carry out the activities of planning, management and organization which constitutes these circumstances.

In its continuation the aim of this research project is to complete a qualitative study on the approach and performance of prime project managers when managing construction processes, focusing a.o. on effective cost management, time scheduling, quality control, defects review and management of suppliers and subcontractors. Moreover, a second aim is to put specific focus on how to implement a positive quality culture in construction projects.

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Implementing Lean construction in a traditional project management culture: Challenges and roadblocks

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Abstract

Lean Construction, and more specifically, the Last Planner System, challenges the foundation of traditional project and construction management practices and their influence in the construction process. This paper describes the problems a client organization faced regarding its request to use Lean construction in a pilot project. It explores the issues raised during the implementation of Lean principles in a project driven by traditional project and construction practices and culture and illustrates the use of constructive research for influencing construction processes. The conclusions are that the move from traditional to lean construction management is a paradigm shift and that the socio-cognitive aspects of changing mental models have been neglected in this process.

Keywords: Lean Construction, Last Planner System, Case study

1. Introduction

Koskela’s (2000) theory describes production in construction as a balance of transformation, flow and value generation. However, construction management practices are only built around the Transformation view: a project is broken down into work packages and related sequences of activities. Dupagne (1991) identifies three problems with this linear division of work: the lack of iterations in the design process; the lack of consideration of constraints within subsequent phases or the unnecessary constraints set in the design of these phases; and the lack of leadership and responsibilities, leading to suboptimal solutions, poor constructability and operability, rework in design and construction and lack of innovation. This could explain why construction is seriously lagging behind other industries in terms of productivity and quality of the end product.

Lean construction is an approach to address these problems that was derived from best practices in the automotive industry. However, it requires drastic changes in practices and culture, which could be a serious challenge in a fragmented industry. This research explores the challenges and roadblocks that a large industrial client organization faced when he decided to apply lean principles in a construction project in the Quebec province. The client, a large international firm, has successfully implanted lean processes in most of its plants and was keen to apply Lean Construction principles to pilot projects in Quebec in an effort to improve project performance. Since the projects were delivered by a large engineering firm through an Engineering Procurement & Construction Management (EPCM) contract, the client organization requested that the project be delivered using the Last Planner System (LPS), a well recognized Lean project delivery tool. The paper describes a constructive research project that analyses the supply chain performance in implementing LPS and provides recommendations for accelerating the adoption of LPS, based on previous research and LPS implementation in Peru (Flores, Salizar and Torres 2000, Bonelli and Carrasco 2000 and Ghio 2001). It outlines the issues encountered in applying these recommendations and the lessons learned from this project.

2. Lean Construction

In recent years, manufacturing has made great improvements in performance, the most notable in the automobile industry where much smaller amounts of resources are used for product development. These improvements are not the result of technological improvements but correspond to the application of a new production theory, "Lean Production", which has its roots in various management principles, including Just In Time (JIT), Total Quality Management (TQM), Time-based Competition, and Benchmarking and Concurrent Engineering.

This new production philosophy is based on the existence of two aspects present in all production system: transformations and flows (Koskela, 1992). While all activities demand cost and time, only the transformation activities add value to the resources (materials and instructions) that are being transformed into a product. Thus, any improvement of the flow activities that do not add any value (inspections, holds, movements) through which the transformation activities are connected, focus on the reduction or elimination of the same, while the transformation activities must execute more efficiently. In the design, control and improvement of construction activities, both aspects must be considered. Howell & Matthews (2005) also describes the inter-relationship between the contractor management of the flow and the successful transformation of materials to the desired end product.

The principles of traditional management, from where the actual project and construction practices and culture are inspired, had considered only the transformations of each of the activities. The transformations desired had been treated as activities that generate value; as a result of these management principles, process flow have not been controlled or improved by means of changes in the management practices of construction activity management. This has led to complex, uncertain and confused flow processes, an increase in non-value added activities and the reduction of the end-product value. The material and information flows are thus the basic unit of analysis of the new production philosophy, which combines three different views (Koskela 2000): production is a transformation of inputs to outputs (traditional approach), production is a logistics flow (the focus of Just in Time), and production is a generation of value through customer requirements (Quality Focus). Thus, time, cost and value are the measure of traditional managements' main characteristics.

Since 1993, a growing number of researchers have joined forces to study and evaluate the results of the implementation of Lean Production in construction, calling it Lean Construction, and sharing their experiences in formal conferences organized by The International Group of Lean Construction (IGLC). Lean Construction is considered as a new paradigm for project management. Its principles and tools were embraced many years ago by companies in several countries including: the USA, the UK, Denmark, Finland, Germany, Australia, Brazil, Chile, and Peru and more recently in companies located in countries such Colombia, China, India, Sri Lanka and Saudi Arabia.

3. The Last Planner System (LPS)

Traditional construction management practices are built around the critical path method (CPM), whose cycle could be described as "Will-Resources-Did". The core principle is that a sequence of activities and tasks are first planned (Will), then resources are assigned to execute these activities (resources) and the control of the execution is done by comparing the planned with the actual activities (Did). This cycle, similar to the transformation view described by Koskela (2000), simply tries to apply the appropriate means to a given resource to produce goods, with no means to learn and improve during the process. There is also no commitment from the resources to meet the time constraints defined in the plan. The result is that an average of about half of the planned activities are delivered according to schedule (Ballard 2000).

To address this issue, Ballard developed the Last Planner System (LPS) a tool designed to enable the practical application of the concepts of Lean Construction. In particular, it proposes a close collaboration between project stakeholders, encouraging the sharing of information among various trades using a resource management pull system. This collaboration is encouraged in part because there is no triggering for when the activities will become necessary for future activities. It is a technique of continuous improvement, with a system of performance measurement and failure analysis.

To facilitate the analysis of each of these aspects, Ballard (2009) proposes a development of means to achieve the two goals of Lean: minimize waste and maximize value. The use of Last Planner occurs at different levels. One level searches to minimize waste-reducing downtime, checking the workflow and reducing the duration of non-value added steps. The other level looks to maximize the value in delivering a product for the customer to achieve its objective better, increasing system control (ability to achieve the objective), delivering the product on time, minimizing disruption of production and responding quickly to disturbances in production.

The vision "Should-Can-Will" is the heart of the Last Planner flow principle. This reflects the determination to make a commitment (Will) to perform an activity (Should) only if it is possible (Can). The verification of constraints release is part of the Last Planner core process. Verification ensures firstly, that the activity is released from any constraint in order to make a reliable commitment, and then that the resources are available as agreed for the activity. The cycle Will-Resources-Did only allows a comparison between what was planned and what was achieved in practice (Mossman, 2008, Ballard et al 2002, Ballard 2009).

The PPC (percentage of planned activities completed) is an indicator to measure the planning and the performance of the production unit. It represents the ratio of completed assignments divided by the number of planned assignments. Studies consider a PPC value above 80% as a good performance, while a PPC value below 60% is considered to be a poor performance. Howell & Macomber (2002) conclude that teams with experience in implementing the system are able to maintain PPC values above 85%.

Finally, there is a noticeable difference between the initial planning done by the Last Planner System (LPS) and the CPM method used in traditional construction practice. In both cases, a maximum compression of the calendar is expected, but once this is obtained, the methods are different. The CPM method will use the compressed calendar as its planning base, not considering contingencies and as a result, project schedules are extended. Instead, LPS divides the initial margin between all activities in order to accommodate variations throughout the project, and to not have to change the sequence along the way. Thus, at the end of the project, LPS will improve the likelihood that each activity’s duration will be reduced, compared to using the estimated CPM with a buffer, and so the project time will also be reduced.

4. Research method

Constructive research is a well-known approach in information technology and in management, a response to the growing concern that academic research had become less and less useful for solving practical problems (Kasanen, Lukka and Siitonen 1993, Lukka 2000). It is a goal-directed problem-solving activity which aims at producing an innovative, theoretically grounded solution for a relevant problem: developing a construct demonstrating its usefulness and usability and determining the scope of applicability of the solution. The case study here is based on an observation of the LPS implementation in a project for which the owner, as part of a business improvement program, wanted to test its use on pilot projects. The project consists of the optimization of a hydro-electrical plant located in the north of Quebec in Canada.

Data collection consisted of triangulation of three methods: interviews, observations (through site visits) and review of project documents. The interviewees included the EPCM Project Control Director, the personnel responsible for the implementation (on the owner's and the EPCM contractor's sides) and the supervisors (EPCM contractor and subcontractors). Observations were focused on planning meetings on the construction site. Schedule and PPC data were provided by the EPCM.

Interventions consisted of reports to the EPCM identifying gaps between the LPS framework and practices observed on site. On-site visits were made, on a weekly basis for the month of March 2011, to participate in the designed “lean meetings”. The principal focus was to observe how these meetings were held and their outputs in order to make improvements in the construction process (coordination reports). Observations were made during the Lean and the daily meetings, and interviews were conducted with the site planning team (both the owner and the contractor sides), project manager and field supervisors (contractor and subcontractors) to obtain feedback about their response to the LPS implementation. The final analysis and discussion covers the performance and the issues that arose from the use of LPS in this project, utilizing Ballard's (2000) LPS framework and Hamzeh and Bergstrom's (2010) implementation steps.

5. Description of the Last Planner implementation

The client, a large firm devoted to mining and transformation, is seeking major improvements in the planning and delivery of its power plants and factories. Quebec is quite rich in minerals and provides easy access to hydroelectricity. However, the construction industry has proved to be unreliable in terms of meeting project targets and delivering a quality product. This client organization successfully introduced benchmarking to track and improve construction project performance. This project is one of the first in the province to experiment with LPS.

The justification for implementing the LPS on this project was to address a specific problem: a lack of physical space to carry out the work where the five main subcontractors of the project had to work to carry out the type of the activities involved, especially given their importance to the project. Prior to LPS implementation, weekly meetings were held in what they called the “conflict zone”. However, the only available tool was the CPM, which does not take these sorts of issues into account. In other words, the LPS was chosen as a tool that could address the problems that the CPM could not. It was expected that LPS would help to avoid delays and improve communication, and therefore the flow of activities between the subcontractors who worked on site.

The LPS is a paradigm shift from traditional construction management practices. In Quebec, the industry is highly fragmented and projects go to the lowest bidders. Introducing the LPS in such an environment is a challenge, since the supply chain changes from project to project. This may explain why this project is the first in Quebec to introduce a lean philosophy in this industry. This client organization benefits from a peculiar context that made this possible: the client, the EPCM and the main contractor company are accustomed to working together in this area. Furthermore, the local main contractor works with the same local subcontractors on other projects. The EPCM is one of the largest engineering firms in Canada. It has developed a rigorous project delivery method based on CPM.

5.1 Phase 1: Planning the implementation of the LPS

The client organization dedicated two people for the planning and supervision of LPS on the project: a six sigma black belt responsible for quality systems in the client's support group for major projects, and an LPS coordinator. The EPCM has no trained resource in LPSs for this project. As a first step, the six sigma black belt prepared an introductory presentation about the LPS to the staff and the LPS Coordinator on the construction site. It included steps for its implementation in a project, and explanations of how the LPS tools work using examples taken from two previous Lean implementations realized for the client organization in the US. In addition, a form of partnering contract was introduced to promote good lean management practices (early warnings, weekly activity updates and planning, the weekly LPS meetings) within the team.

Documents were also distributed to the team explaining the roles and responsibilities of the LPS coordinator, the LPS core principles and methods, how the LPS weekly meetings should be structured, how to make these meetings successful, and how to use the PPC. The client organization's six sigma black belt also held discussion meetings with the LPS coordinator and the EPCM site manager to understand the site process, identify issues and propose solutions on how to reorganize the work according to the LPS.

5.2 Phase 2: Application on the field and PPC calculation

The LPS principal activity was the on-site, weekly "Lean meetings" specific to this conflict area. They were conducted in a room equipped with an electronic white board to coordinate tasks by projecting the plan of that area (Figure 1). The LPS coordinator, the EPCM project manager, the superintendent, the Health & Safety coordinator, and the supervisors for each trade participated in these meetings.

The meetings usually began with a review of the previous week's coordination report to verify the tasks accomplished. The contractor's planner reviewed the previous week's activities with the aim of calculating the PPC, based upon the reports provided as to the completion of the assigned activities from each of the responsible contractors' personnel. Following this, the contractor's planner proceeded to complete the coordination report for with next week's activities. In order to do that, subcontractors had to explain the exact area they were going to occupy over a plan projected using the electronic board (Figure 1). Each subcontractor's responsible supervisor, in turn, marked their job areas and explained their activity plan and the duration of each allotted task (the time measurement was days, detailed to AM or PM). For purposes of clarity, each of the five subcontractors was assigned a different colour. Discussion between the parties was open and everyone contributed to clarifying how a job was going to be done and compromises were planned and negotiated. Early warnings appeared from this open discussion and were considered for the final report version. The resulting weekly plan was immediately printed from the electronic board and distributed at the end of the meeting to each of the participants. At a later stage, the final version was sent by email.

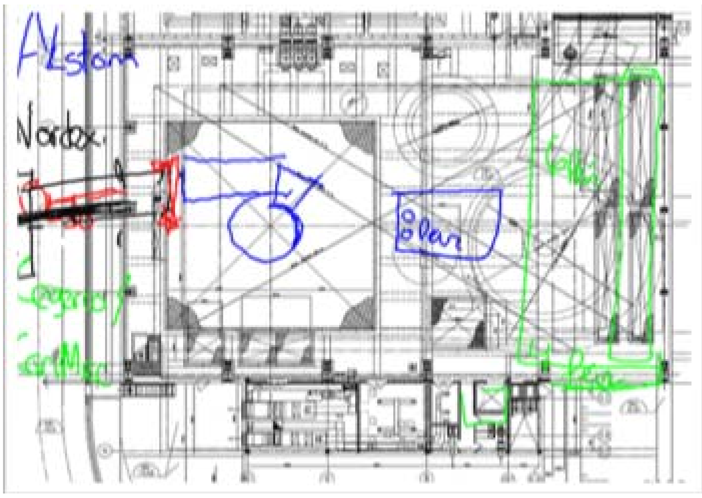

Figure 1: Plan of the conflict area projected on the white board

At these meetings, the planners requested that the subcontractors present a 3 week-Look Ahead Plan (3w-LAP) every 15 days. Once these were received and discussed on site, they were sent to the contractor project control manager in the Montreal office. The only visual information sent from on-site as a result of the LPS implementation were the resulting weekly plans, the coordination reports and the 3w-LAPs and they were solely posted in the room where the “Lean meetings” were held.

5.3 Interventions from the researcher

Following these observations and an analysis of the relevant documents, issues were identified and recommendations made to improve the implementation of LPS and increase the on-site productivity. Suggestions were made during the “Lean meetings”. An LPS theoretical review (Howell, Ballard and others), a study about a successful implementation of LPS by Hamzed and Bergston (2010) and the results obtained in previous studies and LPS implementations realized in Peru (Flores, Salizar, Torres, 2000; Bonelli and Carrasco 2000) provided the theoretical and empirical background for these recommendations.

One of the core issues was the fact that LPS was not used for the whole project but for a specific area. Processes based on two different paradigms (Lean Construction and CPM-based construction management) were used – which led to misunderstandings, overlapping of management tasks and conflicts. For example, daily meetings were held to gain awareness of the progress and the planned activity to consider issues than can arise from a planned activity. Other peripheral activities were also considered in the daily meetings. The information from these daily meetings was not available at Lean meetings and vice-versa. Even during Lean meetings, a traditional WBS structure of activities was the one considered to produce the weekly plan.

The use of PPC was also misunderstood (Figures 2 and 3). Subcontractors considered that the purpose of measuring the PPC was to achieve a global value of 80%. According to Figure 2, this goal was achieved in average. However, the measurement of PPC was inconsistent. For example, even if the activities were achieved on the day they were supposed to, the calculation did not consider if was done at the expected time (AM/PM) and so the causes for its non-completion were not considered. An important dimension of LPS is on-the-site learning: an identification and analysis of the reasons that cause an interruption in each week's the work flow contributes, with time, to a process of continuous learning on the job site, which was not the case.

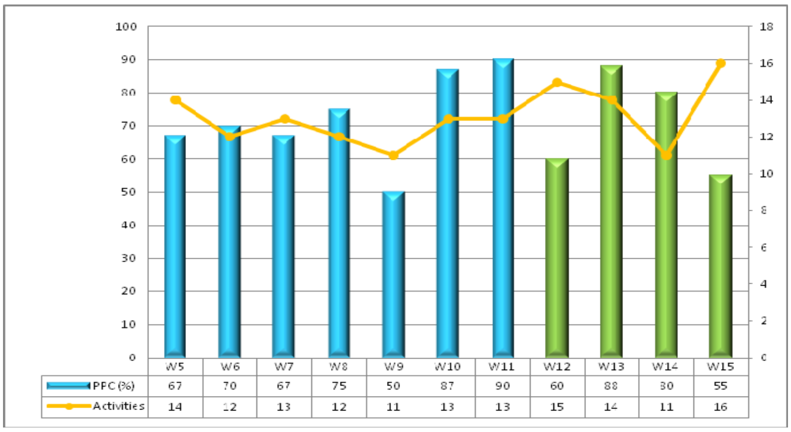

Figure 2: Evolution of PPC

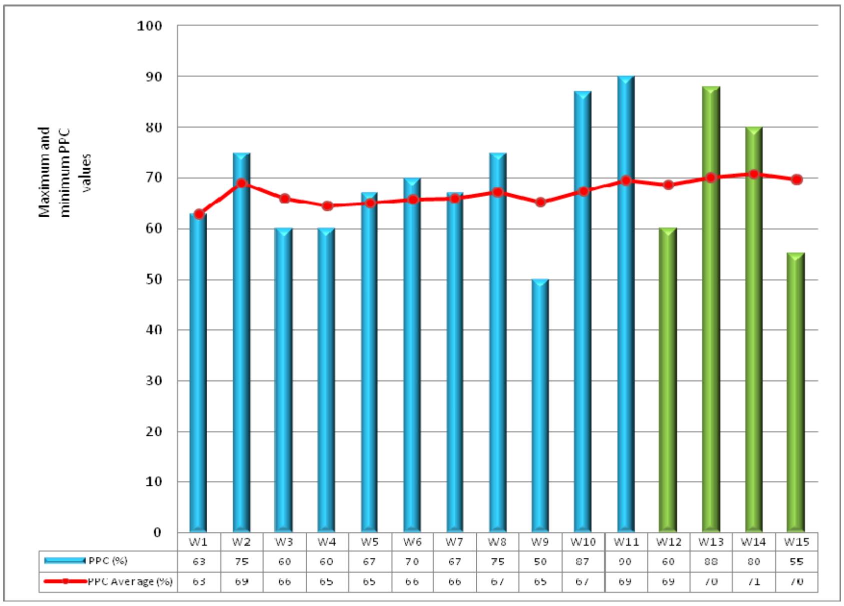

Figure 3: relationships between PPC and number of planned activities

Another important dimension is the quality of the data. An activity cannot be included in the weekly plan if it has not met the 7 conditions for an activity to be started: the input activity has been completed, complete drawings and specs for the activity are available to the workers, all the workers planned for the task are present, they have the equipment and material required to do the job, and external conditions that could impact the work have been identified and taken care. From our interviews, this validation of the activities has not been conducted.

Discussions of our observations and recommendations were held with those responsible for the on-site implementation (the owner-planner and the EPCM-planner) and with the person in charge at the owner's Montreal office. The same points were presented in written reports prepared after each of the visits, in which the same suggestions were made in order to see some changes. These suggestions were not, however, taken in account by the EPCM.

6. Discussion

When the subcontractors of this project collaborated in the implementation, it was observed that the manager responsible for the on-site implementation considered LPS as a methodology more appropriate for the construction-building type of a project with repetitive elements than for this industrial-construction type of project. He considered this project as one of a kind, which is a typical idiosyncrasy founded in other studies.

Excuses such as "the subcontractor will not be able to do more than what we are asking to do because then it will take them lots of time to prepare" or "we have to consider the location of the project" were given when asked why the suggested remedial actions were not applied. If they had been applied, they may have made more improvements possible and/or be make more detail available for the planning process. The simple act of compiling a list of the principal causes of no-completion of a planned activity was considered as akin to "looking for the guilty party". A change of paradigm requires discarding obsolete practices when adopting new ones. The LPS challenges common construction management practices, and so professionals such as planners, construction managers and superintendants will resist the changes. The right conditions have to be put in place for this shift to be successful. Hamzeh and Bergstrom (2010) recommend adopting a series of steps when implementing the LPS, based on the analysis of success factors for LPS implementation: harness the support of the project's owner and the organization's top management, establish a cross-functional nucleus team and develop goals to accomplish, evaluate and map the current planning process, customize LPS to the current project/organization, identify challenges and opportunities, develop and perform a train-the-trainer program, create a positive team experience, and identify and manage recurring issues.

There was strong support from the client organization top management. The implementation of the LPS in the project was discussed at a management level between the client organization and the contractor, and so there was commitment from the head representative of each organization. The problem was with the EPCM who considered this as an additional requirement, and maintained its traditional construction management process. An aggravating factor was that the LPS was adopted to solve a specific problem of communication in a conflict area, not as a new paradigm to improve the performance of project delivery. The evaluation and mapping of the current planning process was made to highlight the gaps between the actual planning process and the LPS. The LPS implementation plan was customized to the project and to its organization, with consideration of the possible challenges of its application by the six-sigma expert. However, there was no core of LPS cross-functional champions to drive the changes, implement the train-the-trainer program, create a positive team experience, or identify and manage recurring issues. Therefore, the conditions were not present for a successful LPS implementation.

Other factors have also played a role in this partial failure. Agreeing with Hamzed (2009), some of the reasons for the partial results of LPS implementation in this project are local and others are more general. A the local level, we can take into consideration that it was the first approach for the on-site team in the use of lean methods, that the project had a traditional management organization and that planning was made following the CPM method. On the general level we can consider the lack of human skills and experience in the utilization of new philosophies or tools and the organizational inertia.

It should be noted that implementing LPS should not be regarded as a simple application of a new tool to a project, as it requires that the people who use it change the way they view and execute their work. The LPS is a lean construction method that requires teamwork and continuous improvement. This implies a real change in the status-quo, which generally intimidates people who have been working "successfully" for years using a traditional management framework without making any changes. Taking them out of their "comfort zone" becomes the primary challenge when implementing the LPS, because the method itself is not very complicated in and of itself. This is symptomatic of the fear of change, something very familiar to those who deal with change management systems, which is why a nucleus of champions is essential to break the socio-cognitive barrier associated with discarding familiar and well-mastered practices.

7. Conclusion

The case study presents the issues facing the implementation of the LPS in a project conducted by traditional, centralized CPM-based planning. The main difficulties perceived for a complete implementation were: lack of training, resistance to change, the contractual structure and the partial and late implementation of LPS. This case also demonstrated the challenges of conducting constructive research in this context.

A key factor in this partial failure is the lack of understanding of the socio-cognitive aspects related to a paradigm shift in construction management practices. It was the client organization's middle management who indicated their commitment to Lean: their goal was to convince the top management of the value of Lean Construction to improve the delivery of projects. The fact that the EPCM top and middle management were not committed is confirmed by their lip service (indicated by adding PPC updates to traditional project management reports, for example) to LPS: PPC graphs were inserted into their standard project management reports, but little effort was made to systematically apply the LPS. It must be considered that the LPS is not a method that can be merely chosen and implemented as needed and that it will work effectively ‘off-the-shelf’. The implementation of LPSs requires deeper organizational changes in ways of thinking, cultural change and the will to move away from the status quo. The same could be said about constructive research. While the EPCM agreed to have the researcher spend 50% of his time at their company to conduct the research and provide recommendations, interventions and access to information for the researcher were not supported.

It is clear that additional, more thorough studies of this method are needed in order to make improvements to the construction culture in Quebec. To support the transition and changes to the complex construction industry and to improve this industry’s efficiency and performance, studies to identify and measure wasteful practices, to measure the common causes of non-completion of activities, and an in-depth study of planning methodologies and construction management are also needed. The results of these studies then need to be shared, rapidly and with a focus on their practical application. To help facilitate this process, educational training is required, including on-site workshops and discussions with management teams, all geared to promote general familiarization with the processes involved and the results that can be achieved. Private and public companies are directly responsible to help achieve these objectives by working hand in hand with educational institutions to publicize and share the results of these studies. The positive results of LPS construction projects in other countries speak for themselves.

8. Acknowledgements

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Integration of sports scientific knowledge in the scheduling of construction projects

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Abstract

The planning of work activities in the course of work scheduling is becoming a greater challenge for construction companies due to short construction time situations and other difficulties, which occur mainly in urban areas. In the current considerations the most important areas are materials logistics (transport, storage and disposal) and equipment logistics (e.g. crane occupation times).

In addition to material and equipment, the construction workers are seen as a valuable resource in recent developments. Therefore their occupation must also be planned in advance.

So far, the manpower planning has been undertaken mainly with the help of resource plans based on the achievable performance of internal standards or literature. The load of construction workers through the various activities and their effects, caused particularly by adverse action sequences were not observed.

From the results of a recently completed collaborative research project by the Institute of Construction Management and Economics of the Technical University Graz and the HPR^{Graz} -Human Performance Research – findings can be utilized to consider these additional parameters.

This allows basic considerations for the placement of breaks during the work cycle with the result of a specific schedule of necessary breaks for highly strenuous activities, the examination of individual stress and thus the forward planning to keep a high performance level throughout the entire workday. Also the prevention of excessive fatigue and thus a reduction of accidents are possible.

In this paper the main results of the research project are presented. Additional it is demonstrated how the points above can be integrated into the preparation of a work schedule.

Keywords: work preparation, scientific knowledge, stress and strain, work load, construction workers

1. Introduction

Nowadays the quality of work preparation is a key indicator of whether a building project is a success or failure for construction companies. Special requirements arise from a very tight schedule, the size and location of the construction site (especially in the Inner City area) and the parallel execution by many contractors and subcontractors. So the economic and technical success of the project is highly affected by work preparation.

2. Initial situation and problems

2.1 Work preparation in construction projects

Current work preparation concentrates on equipment scheduling, material logistics, loading and unloading and nowadays especially on device occupation times. A special service to provide work preparation as an external expert was created as a new field for Civil Engineering.

2.2 Change of the workflow

Work scheduling is suggested as one of the major issues in construction organization. The current debates on demographic changes in many European countries are on significant changes in the consideration about production factors in the construction industry.

Additionally to the classic production factors "human work", "equipment" and "material" (Landau, 2007), the factor "knowledge / human capital" are added by many companies due to the trend towards a knowledge based society in the 21st century. As the preservation of knowledge is strongly linked to professionals who are working for a long time in a company, early retirement and a retirement due to injuries or changeover to a competitor results in a (partial) loss of knowledge.

In the view of the authors, it is therefore very important for the management to take considerations to keep knowledge within the company. Current actions of companies and public facilities show that a lot of companies already are fully aware of this problem and take the first appropriate steps.

The value of a skilled worker nowadays is increasing very fast. In developed countries a big influence is the recognizable for a shortage of skilled workers and a lower numbers of young potentials who start as trainees. Also the steady specialization of businesses or workgroups within an organization creates strictly defined work tasks which are only done by specialized work groups. This described scenario takes place in many major construction companies where one can find workgroups for formwork, masonry work, asphalt work, drywall or other duties; and even their work is divided again into several steps, sometimes executed by different teams.

This increases the problem of a decreased number of skilled workers. Because of the loss of a skilled worker for any reason essential knowledge flows out of the company or at worst a new competitor on the market emerges. Working conditions have to be improved to bind skilled workers longer or even a working life long to the company. This can be done by improving facilities and equipment on the construction sites for the builders; companies have been working on this problem for years and the development has been executed very well in Central Europe.

Additional new considerations like the adaption of work tasks accounting the strain potentials of a specific work task can be used to increase and optimize the output of the existing staff. Thus the circle closes again to work preparation. Through forward planning and wise working arrangement an optimal performance can be generated using the actual employees of the companies. To be able to generate improved work scheduling in addition to material and equipment logistics results of the research project "Work load and work performance curves" can be used.

3. Sports scientific knowledge

Before the new idea for the described additional input based on the application of sport science principles is described in more detail, it is necessary to give a brief overview of some important issues.

3.1 Stress and strain concept

The concept of stress and strain by Rohmert (1983) provides an essential basis for the observation of work activities from a physiological point of view. The underlying concept of this approach separates cause and effect of physical reactions to external influences.

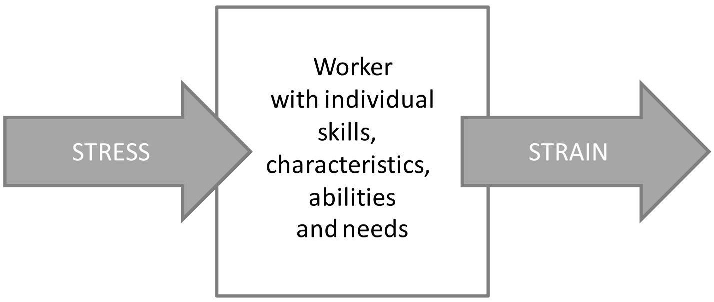

Figure 1: Stress and strain concept of Rohmert (1983)

Different physical reactions and stress levels occur when workers are performing a specific task with the same load caused by their individual characteristics and abilities (Lehmann, 1962; Hollmann and Strüder, 2009).

3.2 Phases of energy supply

The human body derives energy from the source adenosine triphosphate (ATP). For physical activities sufficient quantities of ATP have to be available in skeletal muscle cells. Due to the fact that storage of ATP in the muscle itself is only possible in small scale a continuous supply of the muscle with ATP by the circulatory system has to be ensured (Hollmann and Hettinger, 1990). Energy is produced from ATP with (aerobic) or without oxygen (anaerobic) in the muscle. Aerobic energy supply is longer lasting but can only be used for low to moderate intense muscular activity. At a peak of strain the anaerobic energy production can provide additional energy for a short time (about 3 minutes) (Hollmann and Hettinger, 1990).

According to Hofmann and Tschakert (2011) three phases of energy supply for the metabolism can be distinguished:

- Phase I = aerobic phase
- Phase II = aerobic-anaerobic transition
- Phase III = anaerobic phase

The classification of the phases is based on the changes in individual physiological parameters, as shown in Figure 2.

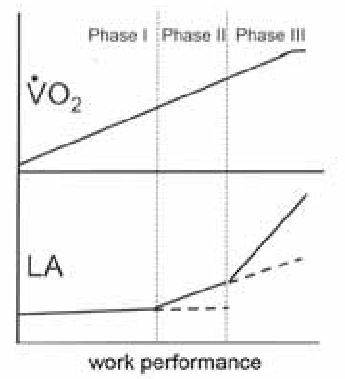

Figure 2: Three phases of energy supply (Hofmann and Tschakert 2011)

Figure 2 shows that the oxygen uptake continuously increases over all three phases; the blood lactate concentration shows a turn point at each transition between the phases. Essential for the further consideration is the phase I for which among other indicators, the LTP1 (first lactate turn point) (Hofmann et al., 1997; Hofmann and Tschakert, 2011; Wultsch et al., 2011) represents the upper level for prolonged work. Until reaching this threshold, the production of energy is carried out only by the oxidation of the fatty acid and glucose and so the supply of the muscles can be provided for extended periods of time without causing severe fatigue.

For the further consideration this phase transition level is defined as the limit for long lasting performance and the strain of work activities is compared to this level. Staying below this level on average for one working day or at least reached in a larger time scale, e.g. a week or a month, a continuous work execution should be possible for several years and without an increased risk of accidents at work. In contrast to this considerations actual studies (Konz, 1998; Wu and Wang, 2002) however indicate, that already an exceeding over the endurance limit for a short period of time the performance decreases due to increased physical fatigue and therefore appropriate breaks should be provided (Pokan et al., 2011).

3.3 Evaluation of the work intensity

In addition to the LTP_1, there are other limits to be introduced briefly. Here we find the following individual maximum load limits:

- Heart rate above the resting heart rate (Pickenhain and Neumann, 1993; Kuhlmann, 1999) ($HR_{8h,av}$=HR_{Rest} + 40 bpm)
- Ratio of oxygen uptake to the maximum oxygen uptake (%$VO_{2\ max}$)
  According to Legg and Myles (1981) values range from 21% to 50% $VO_{2\ max}$. The value of Åstrand (1960) based on investigations of work tasks in the construction industry was set at 40% $VO_{2\ max}$ as an upper limit and is taken in account as the best result for further considerations.

In addition to the individual limits above there are absolute limits, which can be used for classification of the maximum stress of an 8 hours working day

- Mean heart rate during the eight-hour workday (Brouha, 1967; WHO, 1969)
- Mean oxygen uptake during an eight-hour workday (Abdelhamid and Everett, 2002; Lehmann, 1962; Åstrand and Rodahl, 1986)

In addition to these maximum load limits other classification of the intensity of work can be found. Work can also be classified on the basis of heart rate and oxygen consumption in accordance to the considerations of Åstrand and Rodahl (1986) in different levels of work severity. This classification was already used in the construction industry by Abdelhamid and Everett (1999) and can be applied to compare the actual research project with their findings. The classification used by these authors is presented in Table 1.

Table 1: Severity of Prolonged Physical Work and Cardiovascular Response (Åstrand and Rodahl, 1986; Abdelhamid and Everett, 1999)

Work severity	*$VO_{2,mean}$[L / min]*	*HR_{mean}[bpm]*	*$VO_{2,max}$ [L / min]*	*HR_{max} [bpm]*
Very easy work	-	-	*≤ 0.5*	*≤ 75*
Light work	*≤ 0.5*	*≤ 90*	*0.5 to 1.0*	*75-100*
Moderate work	*0.5 to 1.0*	*90-110*	*1.0 to 1.5*	*100-125*
Heavy work	*1.0 to 1.5*	*110-130*	*1.5 to 2.0*	*125-150*
Very heavy work	*1.5 to 2.0*	*130-150*	*2.0 to 2.5*	*150-175*
Extremely heavy work	*> 2.0*	*150-170*	*> 2.5*	*> 175*

However, it has to be mentioned that absolute HR values are dependent on age and relative HR values as a percentage of HR_{max} also (Hofmann et al., 2001; Hofmann and Tschakert, 2011), therefore they should be used with caution.

3.4 Allocation and impact of breaks

Lehmann (1962) defined the recreational breaks as a counterpart to fatigue, in other words a return to a non-fatigued state. Based on various studies it was determined that the characteristic of the fatigue values (pulse, blood pressure, oxygen consumption) have an exponential decline ($A = A_0 * e^{-kt}$). This means that the recovery at the beginning of the break is much greater than after a certain period. Further studies on break duration and frequency were carried out by Müller (1950) and Schmidtke (1959). These studies showed that frequent, short breaks are more effective than a single longer break with the same total duration. Since the arrangement of breaks can´t be done without having a look at the required work flow short breaks often can´t be provided according to these findings. A newer investigation by Konz (1998) determined the length of a break using the strain, represented by the oxygen uptake, to calculate the maximum working time and the required break duration.

Furthermore, it is important to distinguish whether it is an organized or unorganized break. Organized breaks are those which are prescribed by the employer, not organized breaks usually occur while waiting for the next step or arbitrary breaks, set by the workers themselves according to their strain level (REFA, 1984; Schlagbauer, 2006; Schlagbauer, 2011).

4. The cooperative research project

As part of the cooperative research project "Work load and work performance curves" (Schlagbauer, Heck and Hofmann, 2011) sports scientific knowledge was used to design a new prediction method for the production output changes during a work day. This was done to adapt the existing work performance curves of Lehmann (1962) or Burkhardt (1963) and Winter (1966).

4.1 Research design

In this case the research project consists of the development of a model for the reassessment of the output performance and an empirical data acquisition in order to provide a base for the application of the model specifically for the areas of masonry and formwork work (Schlagbauer, 2011). The developed system is shown in Figure 3.

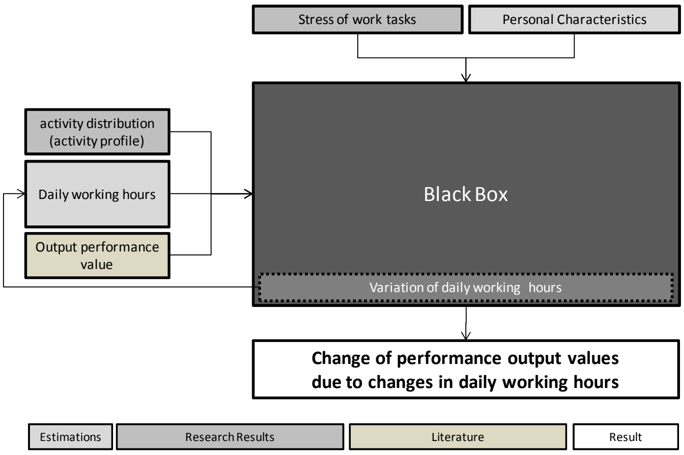

Figure 3: Model for determination of output performance (Schlagbauer, 2011)

In addition, the following input parameters are used for the determination of the work performance curve to the daily working hours:

- the personal characteristics of the person (age, weight, height) to reflect the individuality of the workers,
- the stress parameters of the activities to display the different demands of activities,
- the activity distribution (activity profile) of the working day in order to involve the activity sequences of the working day,
- the output performance values of the activities to calculate the work performance during a working day.

Because there is no literature that considers input parameters beside the personal characteristics and the output performance values for average working conditions, within the research project empirical data was collected at 15 construction sites by observational research of 26 construction workers for 210 days. An overview of the methods, examination and evaluation fields is given in Figure 4 (Schlagbauer, 2011).

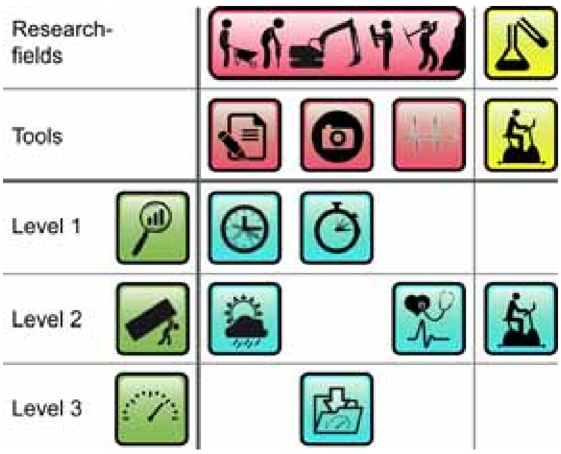

Figure 4: Research Design (Schlagbauer, 2011)

According to Figure 4, the data collection and subsequently the evaluation was done in three levels. In Level 1 - task analysis - the data was collected using the multi- and single moment time recording with an adapted REFA-system for the basic data. In Level 2 - stress and strain survey - additional data was gained by heart rate measurement and recording the climatic conditions. Also a laboratory research was done to receive the personal parameters using a spiroergometry. Finally at Level 3 – output performance survey - the actual performance was determined and connected to the results of the other evaluation levels.

4.2 Objects of investigation

As noted previously, the study only focused on the tasks of bricklayers and formwork setters at multi-storey residential buildings in Graz. Due to this specific sample it was possible to keep the influence by building geometry, construction and transport logistics on the same level. By the selected test period of more than one week, the output fluctuations and the effects of being observed could be reduced. Also by the arrangement of the investigation period after getting to know the site by the construction workers the training effects could be taken out of account. Additional information, collected from interviews, helped to filter teams which have already worked together in a similar composition to minimize another influence parameter. Due to the specific building conditions, the quality of workmanship and the number of construction workers were found to be identical.

The main factor to be discussed with the supervisors was the schedule situation in order to incorporate these into the assessment. It turned out that all construction sites were on schedule with sufficient time buffers (Schlagbauer 2011).

4.3 Results

According to the research design the results of empirical investigation can be divided into three areas. The analyses of activity distribution throughout the work day and in addition the course of the individual distribution within hours are the first results to be displayed:

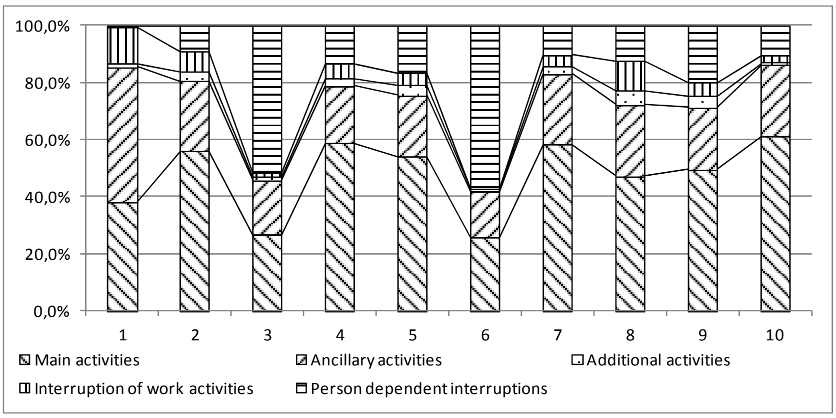

Figure 5: Average activity distribution at the work day for masonry work

In the second analysis level, a multiple regression analysis was done to establish a correlation between the pre-load heart rate ($HR_{pre\text{-}load}$) and the parameters maximum heart rate (HR_{max}) and BMI. It was found that by applying the equation $\%HR_{max} = k + a * HR_{pre\text{-}load} + b * HR_{max} + c * BMI$ based on empirically determined factors a, b and c shows a deviation of only 5.88 % compared to the actual measured heart rates. Therefore the findings are suitable for the use in the construction industry.

To use this calculative simulation, strain analysis for individual work tasks such as “brick laying work”, “concreting”, “formwork work” , “preparation” and “clean up” are needed. Until now, the empirical data acquisitions were done for the work areas of formwork work and masonry work. The results of this individual analysis were displayed in the studies of Schlagbauer (2011) in detail.

The concluding evaluation of production output performance brought out the following results: Due to the self-selection of their working speed the workers had relatively constant performances during the work day and their strain level didn´t rise above the endurance limit. These results were also classified by the construction companies as the usually achieved and for the calculation assumed performance values. A comparison of the research results shows, that they accord well with the values from the known literature (Schlagbauer, 2011).

5. Example of application

Finally, in the context of an example, the application of the calculative simulation should be shown. Therefore in a first step the calculation of the heart rate course for masonry work is done. To show the effects of a highly straining activity, the calculation is redone with the same boundary conditions but for concreting instead of masonry work.

5.1 Heart rate curve for masonry work

To determine the performance, it is necessary to define the input parameters age, size and weight of the worker. For this example, the values are set for age 36, height 180 cm and weight 88 kg. The next step is to define the distribution and sequence of activities. Therefore the distribution obtained from the research project is used. The general task distribution is shown in the figure below.

With these specifications the necessary input parameters for the heart rate simulation can be computed according to Wonisch (2008): $BMI = {}^{weight}/_{height^2} = {}^{88}/_{1,80^2} = 27.16\ {}^{kg}/_{m^2}$, $HF_{max} = 211.30 - 0.922 * Age = 178.11$ bpm and $P_{max,calc} = 6.773 + 136.141 * KO - 0.916 * KO * A = 219.9$ W using $KO = 0.00714 * W^{0.425} * H^{0.725} = 2.07$ m².

The utilization of these input parameters allows calculating the heart rate course over the work day based on the activity distribution. The result for the example is shown in the following figure.

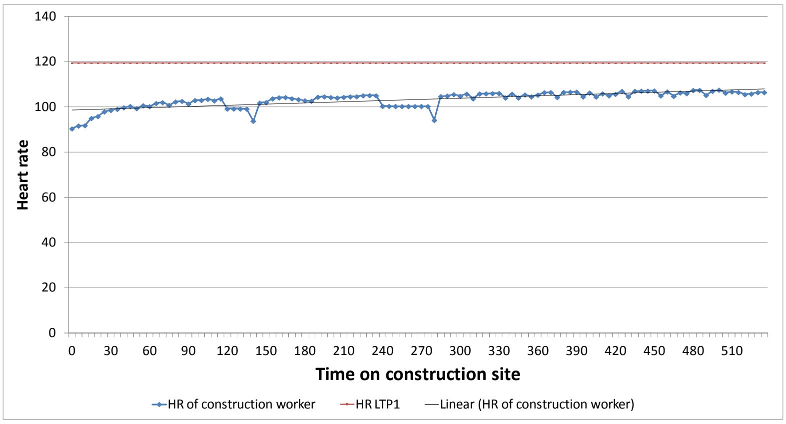

Figure 6: Heart rate course at the work day for masonry work

The comparison with the individual threshold of HF_{LTP1}, determined by using the equation HR_{LTP1}= 2.420+HR_{max}*0.635+ P_{max}*0,018 (Schlagbauer, 2011) indicates, that the heart rate for the considered eight hour work day is still substantially lower than the endurance limit heart rate (HF_{LTP1}) and thus no additional breaks are required. Using the net-work time for the masonry work and the previously determined output performance value the daily work output can be determined.

5.2 Changes of the activity intensity level

To illustrate the impact caused by a higher straining activity, the tasks of "bricklaying" are now replaced by the tasks of "concreting". Coherently also the associated ancillary activities were replaced and again the calculative simulation for the heart rate course was done.

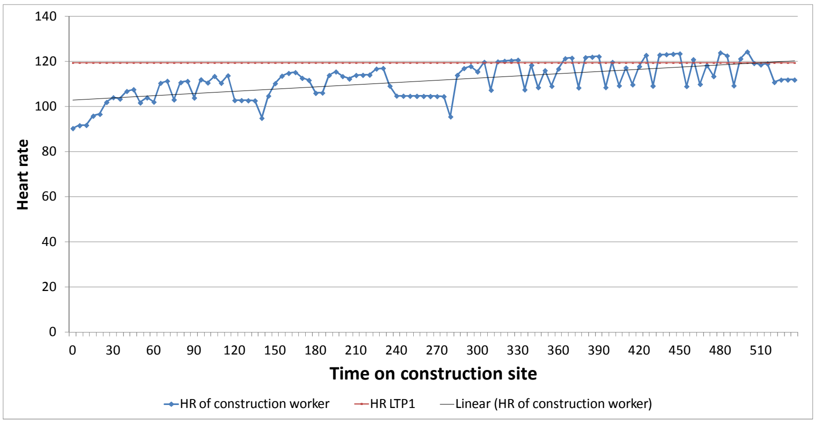

Figure 7: Heart rate course at the work day for concreting work

The change of the activity stress leads to a much higher heart rate during the whole day. It´s recognisable, that the HR_{LTP1} is reached after 305 minutes on the construction site for the first time and after this point the HR_{LTP1} level is often crossed by the calculated heart rate depending on the tasks to be fulfilled.

Looking at the mean heart rates of a day performing masonry work ($HR_{mean,Mas,8h}$=103 bpm) and a day executing concreting work ($HR_{mean,Con,8h}$=112 bpm), it turns out that due to the highly straining work of concreting also the WHO-limit for an 8h work day (WHO, 1969) is exceeded, while for masonry work there is a reserve of 6 %.

6. Summary

In this paper the important role of work preparation in combination with the decrease of skilled construction workers was shown. Also a brief overview of problems for the construction industry concerning the demographic changes of the society was displayed.

A complete solution of this problem can´t be offered because of the different on site situations and various companies that are involved in the construction industry. But, as presented, there are lessons to be learned from other industries and research fields. This supplementary information can be used to obtain an additional evaluation criterion as a planning tool. Specifically, it was shown that concepts of sports scientific knowledge can be used for the determination of the endurance limits.

The practical implementation of the heart rate value at the first lactate turn point (HR_{LTP1}) as an upper limit for continuous work without a declining productivity could be one of the first steps to build up work processes in consideration of the strain caused be the construction tasks.

The importance of a strain derived work flow was shown in the example application by the change of the tasks to be done. Performing work tasks with a higher stress level lead to an immediately increase of the heart rate and an exceed of the heart rate limit for continuously working without fatigue caused by physiological demands (HR_{LTP1}).

7. Acknowledgements

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The influence of procurement methods on project performance: A conceptual framework

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Abstract

Project performance is highly influenced by the type of construction procurement method used to deliver the project. By virtue of this relationship, project clients often seek to select the best method that will help achieve better project performance. Although a lot of studies have been done with the view to developing models/tools for aiding the selection process, there is very little research that have looked at how procurement methods actually influence project performance. As a contribution in this regard, this paper reports on a conceptual framework that demonstrates the existence of this influence. The framework, developed based on extensive review of literature, forms part of an on-going wider study aimed at developing a quantitative model for establishing exactly the nature and level of the influence that exists. The review was carried out to determine the main criteria for selecting procurement methods and for project performance measurements. Thirteen (13) procurement selection criteria commonly cited in the literature were identified. A review on how each of these criterion suits the use of Traditional procurement method and Design and Build were also carried out. This latter review is to facilitate ranking of each of the criterion on a rating scale for purposes of predicting the actual level of influence a particular procurement method exerts on performance of a project. Besides offering a deeper understanding of procurement method relationships with project performance, the proposed conceptual framework forms basis for the development of the quantitative model at subsequent stages of the on-going study. The model's main objective is to serve as a tool for identifying which procurement method is likely to result in poor performance or vice versa, for any given project. This, hopefully, will assist clients in their procurement selection task, particularly for clients where the use of any of the existing selection model is not applicable.

Key words: Construction procurement strategies, traditional procurement method, design and build, procurement criteria, project performance criteria

1. Introduction

The term ‘construction procurement method’ has been given different definitions in the literature. For instance, Chan (2007) defined it as the system that represents the organizational structure adopted by clients for the implementation of project processes and eventual operation of the project. On the other hand, Molenaar *et al*. (2009) defined procurement method as a comprehensive process by which designers, constructors, and various consultants provide services for design and construction to deliver a complete project to the client. As this definition suggests, wide range of processes are involved in a procurement strategy. These processes are often interrelated and sequential in nature and their effectiveness and efficiency impact considerably on the success or failure of projects

In addition, the last few decades have witnessed the proliferation of numerous different types of construction procurement for delivering projects. The most common types include: Traditional Method (also known as Design, Bid and Build (DBB) approach), Design and Build (DB), Management Contracting, Construction Management, Project Finance and Partnering. They differ from each other in terms of allocation of responsibilities, activities sequencing, process and procedure, and organizational approach in project delivery (Abdul Rashid et al., 2006; Alhazmi and McCaffer, 2000). The complex nature of procurement selection and their subsequent management therefore pose great difficulties to clients and any failure to rise up to this challenge has often resulted in poor project performance. Such consequence has long been recognised by a number of researchers (Mohsini and Davidson, 1991; Molenaar et al., 2009). Various attempts have thus been made by researchers over the years towards addressing these procurement issues.

The studies done so far can be put into three categories. The first category involves studies that compare existing procurement methods in a bid to find out their efficiencies as used in practice (see for e.g. Mohsini, et al., 1995; wardani, et al, 2006). The second category involves research carried out to identify the criteria or factors that determine the right procurement method to use (for e.g. Alhazimi and McCaffer, 2000, Luu et al., 2003 and Hashim et al., 2008). The third category of the studies, focus on using these criteria to develop models by which clients can employ to select the most suitable procurement method. For instance, Chan (2007) developed a procurement selection model called fuzzy procurement selection model. It is a mathematical rank model that is adaptable to local circumstances. Alhazmi and McCaffer (2000) proposed a model called project procurement system selection model (PPSSM) for assisting government agencies in Saudi Arabia to select the most appropriate procurement method. The model consists of four screening levels to be followed in selection process: feasibility ranking, evaluation by comparison, weighted evaluation, analytic hierarchy processes. Based on a Delphi study, a multi-attribute decision analysis was used to develop a procurement selection model by Chan *et al*. (2001). Luu *et al*. (2003) developed a procurement selection model based on case-based reasoning (CBR) approach. The suitability of CBR approaches was subsequently examined in a study by Luu and Chan (2005), who indicated that the approach has the potential to ensure high quality decisions on procurement selection. The approach was also found to deal effectively with variability in the characteristics of the clients, project and extremely environment.

However, there seem to be very little research reported in the literature on which aspects of procurement method and/or features has the most influence or otherwise on project performance criteria. Such information will be of invaluable benefits to clients, such as helping them to understand the aspects of procurement methods they need to concentrate on to improve project performance. As a contribution in this direction, this paper reports on a conceptual framework developed as part of a wider on-going study aimed at developing a model on the relationship between construction procurement selection criteria and project performance criteria. The framework, developed based on extensive review of the literature, not only seeks to establish the basis of the relationship between these criteria, it also aims to serve as the basis for developing a quantitative model (at later stage of the study) for establishing the exact nature and level of the influence procurement method exerts on project performance.

The rest of the paper is structured as follows. First, a review on factors influencing the selection of suitable procurement methods is presented followed by project performance criteria review. Subsequently, review on DBB and DB procurement methods with their suitability in the light of key selection criteria are presented. This is then followed by a proposed conceptual framework on influence of these criteria and project performance. The final section of the paper presents a summary and key conclusion.

2. Construction Procurement Selection

As highlighted in the previous section, the different procurement methods now available has partly made clients' decisions to adopt any of the method for any given project a complex task to grapple with. Various factors have to be taken into consideration before any informed decision can be made on the right procurement choice. The factors can be classified into two groups (Love *et al*., 1998; Luu, and Chen, 2005; Ratnasabapathy et al. 2006):

- External environment such as economics, politics, finance, legal, nature disasters, technology factors and;
- Internal environment which can be divided under three main factors; project characteristics, client's characteristics and client's requirement.

Client requirements can be sub-divided into cost related factors, time related factors and quality related factors. All these factors and their relationships have been nicely summarised by Ratnasabapathy et al. (2006) in Figure 1 below. The figure shows how the factors relate and interrelate with each other, which go to explains how the task involved in selecting the right procurement method can be extremely complex and difficult. The nature of the selection process therefore calls for employment of sound systematic procedure by clients. Such approach is likely to yield the best procurement method that best meets the needs for a particular type of works (Ali et al., 2011).

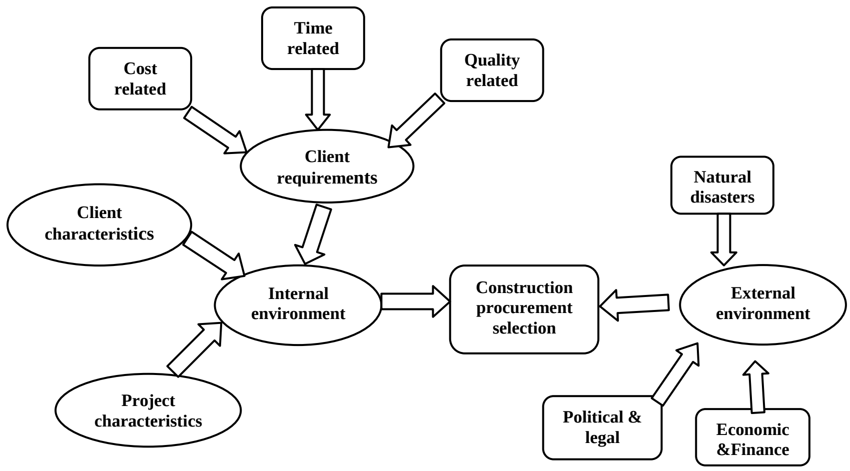

Figure 1: Factor effecting selection of a procurement method (Source: Ratnasabapathy et al. 2006)

According to Love et al. (2008), the selection of an appropriate procurement strategy has two main components. The first component involves analysing and establishing priorities for project objectives and client attitudes to risk. The second involves considering possible options, evaluating them and finally selecting the most appropriate. The accuracy and clarity of the client's requirements and needs are crucial ingredients here. Fortunately, the selection criteria to be used have been researched extensive and documented in the literature. A critical review of the literature suggests that there are 13 procurement selection criteria that are commonly cited in the literature (see Table 1). The review was restricted to studies conducted from 1998 to date, as the adoption of different procurement routes is relatively new in the construction industry. These criteria thus represent the most current criteria that are of relevance to procurement selection for which researchers involved in further development of the selection process should find beneficial.

3. Project performance criteria

Traditionally, a project is considered to have achieved a high level of performance if it is delivered at the right time, right price and good quality level. It should also provide the client with a high level of satisfaction. Bryde and Brown (2004) concluded that the traditional distinction between good and poor project performance focused on the meeting of cost, time and product quality-related criteria. These criteria have been described as the iron triangle of project performance. Figure 2 shows the iron triangle as adopted by Atkinson (1999)

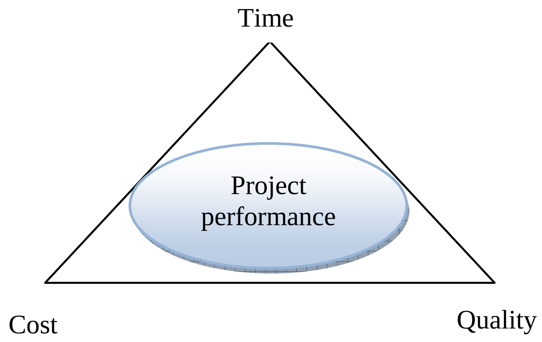

Figure 2: Project performance criteria trade-off triangle (source: Atkinson, 1999)

Project success is usually measured differently from the perspectives of the different parties. Jing et al. (2010) compared success criteria as measured by contractors and clients and found out that clients put more emphasize on satisfying the needs of other stakeholders, while contractors emphasis on minimizing project cost and duration. They also found that all project stakeholders put products satisfying owner's needs as the first criteria.

In last decades, several researchers within the multidimensional construct of project performance have proposed different criteria or indicators based on empirical research. While some focused on using these measures as strategic weapons, others emphasized the proper delineation of the measures and groupings into classes that will make tracking and management reasonable. Most of the studies (see for example, Bassioni et al., 2004; Jin et al., 2007; Cheung et al., 2004) agree that project performance can be measured and evaluated using a large number of performance indicators or criteria but time, cost and quality appear to be the three commonly preferred performance evaluation dimensions.

Table1: Criteria for selecting construction procurement method

Procurement criteria / *Authors*	*Price certainty*	*Price competition*	*construction Speed*	*Time certainty*	*Quality level*	*Integrate design & construction*	*Effective communication*	*Flexibility of changes*	*Clear Scope definition*	*Complexity of design*	*Allocation of responsibility*	*Client involvement*	*Controllable variation*
Ratnasabapathy et al. (2006)	-	✓	✓	-	✓	✓	✓	✓	-	✓	✓	✓	-
Hashim et al. (2008)	✓	-	-	-	✓	-	-	-	✓	✓	✓	-	✓
Seng & Yusof (2006)	-	✓	✓	-	✓	✓	✓	-	✓	-	-	-	-
Alkhalil (2002)	-	-	-	-	-	-	-	-	✓	✓	✓	✓	✓
Cheung et al. (2001)	✓	✓	✓	✓	✓	✓	-	✓	✓	✓	✓	-	✓
Luu et al. (2003)	✓	-	✓	-	✓	✓	-	✓	-	✓	✓	-	✓
Luu, Ng & Chen (2005)	-	✓	✓	✓	✓	-	-	✓	✓	-	✓	✓	-
Love et al. (1998)	✓	✓	✓	✓	✓		-	✓	✓	-	✓		✓
Masterman & Gameson (2010)	✓	-	✓	✓	✓	✓	✓	✓	✓	-	-	✓	-
Hibberd & Djebarni (2010)	-	-	✓	-	-	-	-	-	✓	-	-	-	-
Edmond et al. (2008)	-	-	-	-		-	✓		✓	✓	✓	✓	✓
Chan et al. (2001)	-	✓	✓	-	✓	✓	✓	✓		✓	✓	✓	
Alhazmi & McCaffer (2000)	-	✓	✓	-	-	✓	-	✓	✓	-	✓	✓	✓
Chan (2007)	✓	✓	-	✓	✓	-	-	✓	-	✓	✓	-	-
Total	*6*	*8*	*10*	*5*	*10*	*7*	*5*	*9*	*10*	*8*	*11*	*7*	*7*

4. Procurement methods and their influence on project performance

4.1 Traditional procurement method (DBB)

Traditional procurement is the oldest form of construction procurement. It is considered as a popular form of separated-and-cooperative procurement method. It can be defined as a project delivery strategy in which two separate organizations (design team and contractor) do carry out all project processes and are individually responsible directly to the client (see Figure 3 below).

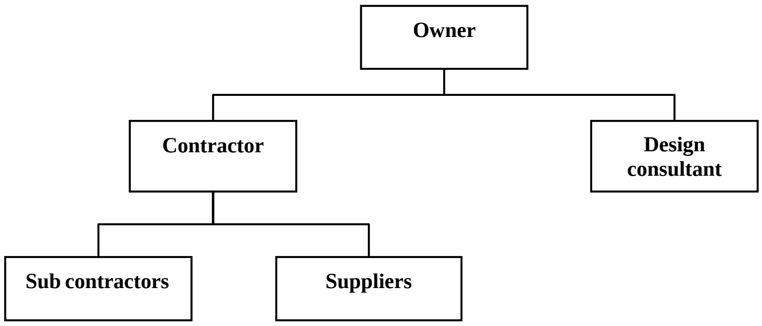

Figure 3: Project organization structure for DBB method

The circumstances in which this method is generally considered appropriate include the following:

- The service of a designer has already been procured
- The designer is experienced enough to oversee both the design and construction
- The design is substantially complete by the time the contractor is selected
- Contractor is selected on the basis of price with a general acceptance that the price may be wrong
- It is important for client to use a contract form with fair and familiar distribution of risk
- When neither the employer or his advisers raise this as an issue
- Full tender documentation exist to ensure price certainty
- The bill of quantities can be used for valuing variations
- Client desires competitive tendering
- Scope of work is clear and well defined to facilitate detailed design

4.2 Design and Build (DB)

It is classified as one of the integrated form of procurement method, whereby the client provides his/her requirements and needs for the specified project and signed contract with only one organization namely the contractor. This organization is responsible for the design, supervision and construction services of the project as Figure 4 below depicts.

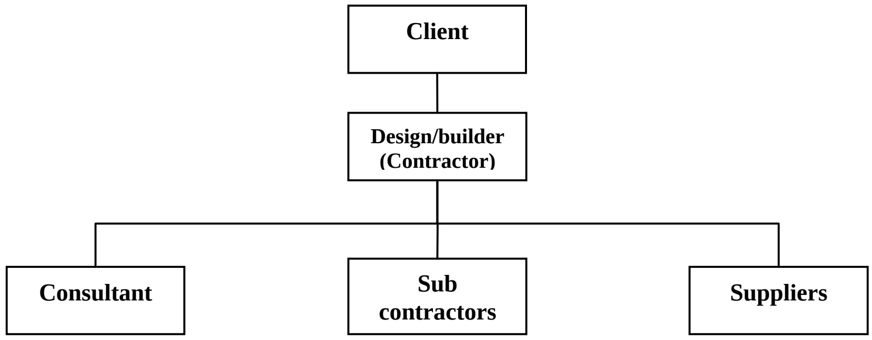

Figure 4: Project organization structure for DB procurement method

The circumstances in which this approach is generally considered appropriate include the following:

- Client not familiar with the construction process
- Project is technically complexity
- There is a low likelihood of variations to the project
- Client desires a single point of responsibility
- The employer desires a quick start to work on site
- Client desires to prioritize either – time, quality, price or value for money etc.
- Client desires an opportunity for effective direct communication/interaction with contractors
- Client desires for an integration of the design and construction process

5. A conceptual framework on influence of procurement methods on project performance

Figure 5 shows a conceptual framework that illustrates how knowledge of procurement selection criteria can help establish their impact on project performance. Each of the criterion could impact differently on time, cost and quality, depending on the suitability of the criterion with respect to a given procurement method. The extent of influence each criterion exerts for any given project could be determine by assigning a number using a scale of 1-7; where 1-3 indicates negative influence on performance and 5-7 indicates positive influence, with 4 as no influence or neutral. The criteria to be used are the 13 factors identified from literature and presented in Table 1. The suitability of these criteria as far as DBB and DB methods are concerned would also be rated to enable each method's influence to be established. Table 2 provides a list on suitability information (as reviewed from literature) to aid with this assessment. It must be noted that out of the many procurement methods available, only these two were focussed on as they are considered the most commonly used strategies (Molenaar et al., 2009; Masurier et al., 2006).

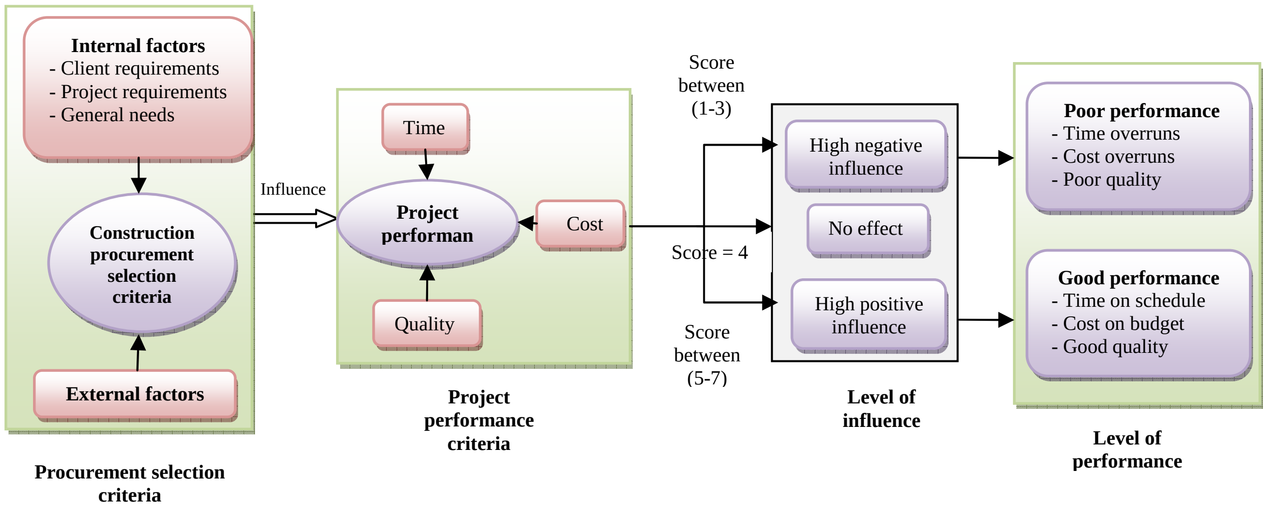

Figure 5: Conceptual framework of construction procurement influence on project performance

Table 2: selection procurement criteria for traditional method and design and build method

	Criteria	*Traditional (DBB)*	*Design &build (D&B)*	*Authors*
1	*Price competition*	*(DBB)*	-	*Cheung et al. (2001), Luu et al. (2003), Luu, Ng & Chen (2005), Love et al. (1998), Chan et al. (2001), Alhazmi & McCaffer (2000), Hashim et al. (2008), Ratnasabapathy et al. (2006), Ng et al. (2002)*
2	*Clarity of scope definition*	*(DBB)*	-	*Alkhalil (2002), Thomas et al. (2002)*
3	*Complexity of design*	*(DBB)*	*(D&B)*	*Cheung et al. (2001), Luu et al. (2003), Love et al. (1998), Chan et al. (2001), Hashim et al. (2008), Ratnasabapathy et al. (2006), Edmond et al. (2008), Chan (2007), Seng & Yusof (2006), love et al. (2008), Ng et al. (2002)*
4	*Quality level*	*(DBB)*	-	*Cheung et al. (2001), Luu et al. (2003), Love et al. (1998), Chan et al. (2001), Hashim et al. (2008), Ratnasabapathy et al. (2006), Chan (2007), Seng & Yusof (2006), love et al. (2008), Alkhalil (2002), Luu, Ng & Chen (2005), Masterman & Gameson (1999), Alhazmi & McCaffer (2000), Thomas et al. (2002), Ng et al. (2002)*
5	*Client involvement*	*(DBB)*	-	*Alkhalil (2002), Edmond et al. (2008), Chan et al. (2001), Alhazmi & McCaffer (2000), Ratnasabapathy et al. (2006)*
6	*Flexibility of changes*	-	*(D&B)*	*Cheung et al. (2001), Luu et al. (2003), Luu, Ng & Chen (2005), Love et al. (1998), Masterman & Gameson (1999), Chan et al. (2001), Ratnasabapathy et al. (2006), Chan (2007), Ng et al. (2002)*
7	*Controllable variation*	*(DBB)*	-	*Hashim et al. (2008), Alhazmi & McCaffer (2000)*
8	*Speed of construction*	-	*(D&B)*	*Seng & Yusof (2006), Luu et al. (2003), Masterman & Gameson (1999), Alhazmi & McCaffer (2000), Chan (2007), Hibberd & Djebarni (1998), Ng et al. (2002)*

9	*Time certainty*	-	*(D&B)*	*Seng & Yusof (2006), Cheung et al. (2001), Hibberd & Djebarni (1998), Ratnasabapathy et al. (2006)*
10	*Effective communication*	-	*(D&B)*	*Seng & Yusof (2006), Edmond et al. (2008)*
11	*Allocation of responsibility*	*(DBB)*	-	*Alkhalil (2002), Luu et al. (2003), Luu,Ng & Chen (2005), Love et al. (1998), Chan et al. (2001), Alhazmi & McCaffer (2000), Hashim et al. (2008), Ratnasabapathy et al. (2006), Chan (2007), Ng et al. (2002)*
12	*Integrating design and construction*	-	*(D&B)*	*Chan et al. (2001), Alhazmi & McCaffer (2000) Ratnasabapathy et al. (2006)*
13	*Price certainty*	*(DBB)*	-	*Luu, Ng & Chen (2005), Love et al. (1998), Hashim et al. (2008), Ng et al. (2002)*

6. Summary and Conclusion

Different forms of construction procurement methods are available for clients to choose from. Each form differs from the other in term of allocation of responsibilities, activities sequencing, process and procedure and organizational approach in project delivery**.** It is well established that these methods have strong relationships with project performance outcome (time, cost quality), making the selection of the most appreciate method an important decision for every project. Yet such decisions pose difficulties to clients, partly due to the complex task involved in trading-off various numerous factors that underpin the selection process. These factors have received a lot of research attention over the years with the aim of aiding the selection process through the development of models/tools. However, an area that has received very little research is how procurement methods affect project performance.

As a contribution in this regard, a conceptual framework on how the methods influence project performance has been developed, which seeks to offer a deeper understanding of this subject matter. The framework was developed based on intensive literature review, which was used to identify the various procurement selection criteria and the suitability of DBB and DB methods as far as each criterion is concerned. Thirteen (13) procurement selection criteria were identified as the most commonly cited in literature. These are: price competition, price certainty, construction speed, time certainty, quality level, integrates design & construction, effective communication, flexibility of changes, clear scope definition, complexity of design, allocation of responsibility, client involvement, and controllable variation. A review on how each of these suits the use DBB and DB were also presented which will facilitate their ratings on a scale, which would be used to predict the actual level of influence a particular procurement method exerts on the performance of a project.

Developing this framework forms part of a wider study aimed at developing a model that would establish exactly the nature of the relationship here. Such a model has potential benefits to clients, who could employ them to identify which procurement method is likely to result in poor performance or vice versa. This will be particularly helpful in construction industries where the use of any of the existing selection model is not applicable.

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The tasks of site managers

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Abstract

Site managers, foremen and technicians represent the construction company on site and ensure the qualitative and timely realization of the construction work according to a defined budget, as well as the fulfillment of the contract. They represent the management within the "temporary business" construction site.

There is generally a funded knowledge of the tasks and requirements for site managers. However, in the respective literature there are no detailed descriptions of the individual tasks carried out by them. Neither, there exists a typical weekly time schedule for these tasks. For executives of construction companies broad knowledge of the activities and their distribution is a prerequisite for the proper staffing at the site. Site managers themselves can also optimize their own work by using their task profile and the corresponding time schedule. An increase in productivity as well as satisfaction and motivation by eliminating "time robbers" is the positive consequence.

Through an empirical investigation of site managers, foremen and technicians on several similar large-scale construction sites, using the REFA- time analysis method (REFA = Association for work design, operational organization and business development), task profiles for site managers were compiled. The analysis of more than 1000 working hours of site managers brought statistically significant results.

The article describes the basics and the procedure of data collection and data analysis. The results of the investigation are presented and critically examined. Furthermore, the possible applications of the task profiles in terms of human resource development and capacity planning are discussed.

Keywords: site manager, foremen, task profile, human resources, time analysis

1. Introduction

The requirements for construction managers are generally as broad as the spectrum of the projects which they work on. They vary mainly depending on company size, type and complexity of the project, the agreements in the construction contracts as well as the position of the individual site manager within the company. These requirements are further affected by the project environment as well as current laws and regulations. There are several reasons why those requirements for the site management team need to be examined more closely:

1) Constant changes in the technological and organizational outline conditions of the site management`s work result in a permanent change in his or her qualification and further education. At the same time the site management constantly gains new experience, know-how and abilities due to the involvement in projects and the potential participation in training measures. The qualification of site managers is a fundamental requirement for ensuring the accomplishment of a project. Therefore it’s necessary to know what the main tasks of the construction management are; only then companies can initiate further specific education measures for their employees and achieve a competitive advantage.

2) In the last few years, there has been a growing emphasis within research and practice on the need to develop and improve the performance of contractors' project managers in order to meet the increasing demands being placed on the industry by both its clients and governments (Dainty et al., 2003). Performance can only be enhanced if the work processes and tasks are well known.

3) Site managers, foremen and technicians must fulfil a number of roles including those of facilitator, co-ordinator, motivator and politician (Briner et al.,1996). If site managers get transferred too much work, they are in danger of suffering overload. It is important to know what tasks are “time robbers” and what tasks could be delegated to others, or when it is time to send another manager on the construction site.

4) A quantification of the required number of site managers is usually carried out by project experience or by estimating. There is no structured quantification method. Many projects are planned with too little management capacity. The consequences are the recruitment of additional resources and, consequently, additional costs and the need to restructure the construction management team. As a basis for a quantification model it is necessary to know about the average time that the management would need to get its tasks done.

5) For job advertisements, it is important to give an accurate description of the specific job requirements. A professional profile derived from the actual activities can help to find appropriate staff for the work.

These reasons and the fact that construction management literature usually only roughly divides the activities of construction management into preparation, execution of construction, negotiations and personnel matters (Kühn, 1991), makes it necessary to make a further breakdown of activities.

The results which are shown in this paper are part of a research project entitled "Quantification of construction site managers", which considers the aforementioned reasons, as well as various factors influencing the construction management. The aim is to develop an instrument for determining the optimum number of members of the construction management team already in the bidding phase.

Due to the objective of the research there is a very large and complex study object. Because of that, certain restrictions were made for the study. The focus of the study is on:

Projects: over 4,0 Million Euro; structural engineering; general contractors contract in Austria

Companies: within the 10 biggest companies of Austria

2. Site management

This chapter deals with the definitions of the project team members and furthermore with the classification of construction site management in the structure of a construction company, as well as in the project structure. This is important because in several countries different terminology is used. The term construction management is used in this paper as a synonym for the entire site management team. This team consists of site managers, foremen and technicians of a construction company.

2.1 Definitions

Site manager

Site manager is the usual term for a construction expert, who is the responsible representative of a construction company. He or she is entitled to give instructions to several parties involved on site, for example, employees, subcontractors, craftsmen, etc. For the entrepreneur, he or she directs and controls the building's creation on the basis of recognized rules of technology, taking into account the legal concerns (Biermann, 2005). Site managers usually have a good technical (University) education and/or several years of experience.

Technicians

As site manager, but with limited authority, responsible for major construction sites, mostly for specific subtasks. They have a technical education, and switch after several years of successful professional experience to the profession site manager.

Foremen

Foremen stand hierarchically between the site manager and the construction workers. They oversee and coordinate the workers and are the first contact person for their questions and technical problems. Foremen have a high professional education and expertise.

2.2 Position in the organizational structure

The head of the construction company is the board of managing directors, often divided into a commercial and a technical section. Under that management departments are located, which are responsible for different areas of construction. The head of a department is sometimes also supported by a commercial and a technical direction, and might also be involved in project management, especially for very large projects. The site management is on site throughout the project. The site manager has to ensure the qualitative and timely realization of the construction work according to a defined budget, as well as the fulfillment of the contract. The site manager is responsible for the site, and reports directly to the department. The technician takes over partial duties of a site manager but carries less responsibility and reports to the site manager. The foreman is the link between the management and the workers. Figure 1 shows the typical organizational structure in a construction company for a medium-sized site.

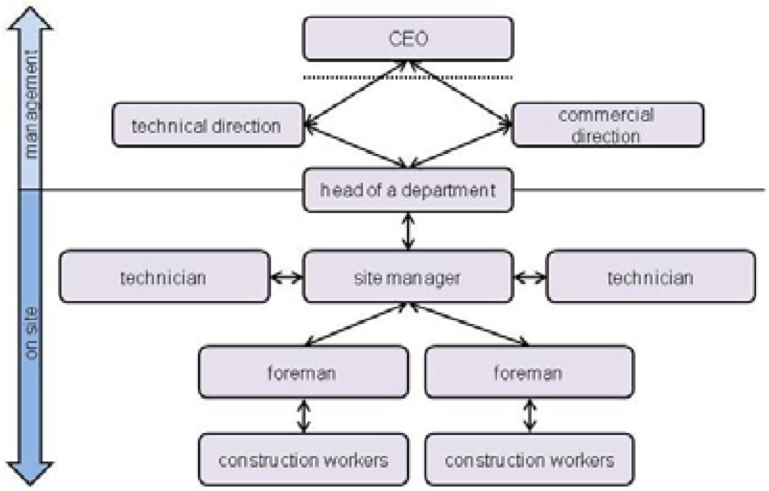


Figure 1: Typical organizational structure for a medium-sized site

The interfaces of the job field of construction management are depending on the size of the site and the number of participants, including professional planners, subcontractors or internal specialized departments. Smaller projects are often managed by technicians or foremen alone, so that some interfaces fall away. Figure 2 shows the integration of site management in the project environment. In the center of the observed structure is the construction management. All decisions and information are communicated through and with the site management.

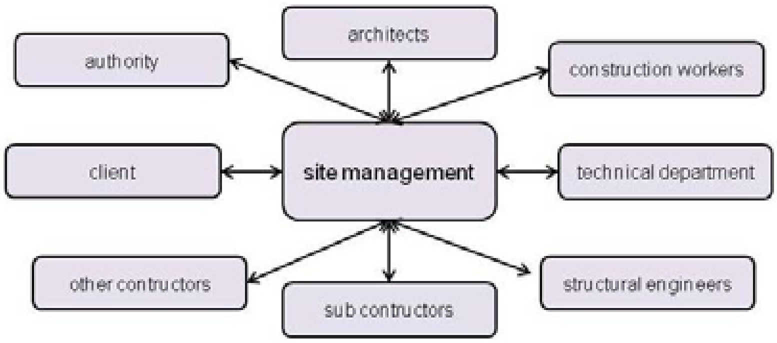


Figure 2: Integration of site management in the project environment

3. General task profile

The entire tasks and activities of the construction management, like planning tasks, scheduling appointments or control functions can not really be separated from each other, because they are too closely linked and are directly related to the expiration of the construction site (Berner, 1981). Through the planned procedure and the occurrence of particular incidents, tasks arise that are only short term and others that extend over long periods of time. However, there are numerous reasons (see Chapter 1) to further investigate the tasks and responsibilities of site management.

The image of the construction management work is characterized by the different work areas. In the respective literature (Berner, 1981; Biermann, 2005; Cichos, 2007) the following outline of activities is often chosen:

- **Disposition activities:** the disposition or decision on the application of labor, machines and materials. For example getting a new work unit, ordering concrete, requesting a mobile crane.

- **Control and monitoring activities:** make sure that instructions which were given, either orally or dictated by plans, were executed properly. This could be routine monitoring or necessary inspections. Furthermore, it must also be checked whether all safety regulations are adhered to. For example, check concrete for consistency, random control measures, check out the authorized dimensions of scaffolds.

- **Information activities:** information about points that have to be clarified either with external or internal parties. For example, discussions on technical issues, weekly status report to the superiors.

- **Planning activities:** a process that is composed of gaining information and processing operations and serves as a preparation for future action. Through planning, goals and measures can be implemented in short or long term. For example, create a detailed schedule.

- **Meetings:** exchange of views on operations, which are either known in advance or occur suddenly and unexpectedly. Vital part of communication within the project team and the communication with persons involved. For example, daily discussions in the team, weekly meetings with the superior, meetings with the client, meetings at the beginning of the project.

- **Administration activities:** handling of paperwork and documentation. For example, filling out the daily reports, protocols of meetings, correspondence with participants as part of the claim management.

In addition to the fields of activity there is also the area of responsibility for the site management. In German legislative law there are several special provisions for the construction industry, especially for the site management. For example, “those who violate the generally accepted rules of technology and thereby endangers the life of another shall be punished with imprisonment of up to five years or an appropriate fine” (§ 319 STGB, 2012). Unfortunately, the site management is not always aware of how responsible their function is.

In the next chapters, only the situation of the site managers is considered in more detail. In the research, project data was collected in an identical manner for foremen and technicians.

4. Methodology

Survey

As a first step of the investigation a questionnaire was conducted to examine the scope of the individual activities shown in chapter 3. A pilot study was carried out on three site managers and two executives to ensure the clarity and relevance of the questionnaire. Based on the feedback received, minor changes were made to the questionnaire to remove any ambiguities and discrepancies. A total of 26 survey forms were sent to specific building contractors. The target group of this study were site managers with more than five years experience as well as executives. The limitations for the research project also apply to the survey (see focus of the study, chapter 1).

26 survey forms appear to be very few. The reasons for this is that the number of participants was limited by the restrictions and the site managers were specifically selected in advance. This was

important for the further investigations. With this survey basics should be collected. The procedure for the survey is shown in Figure 3.

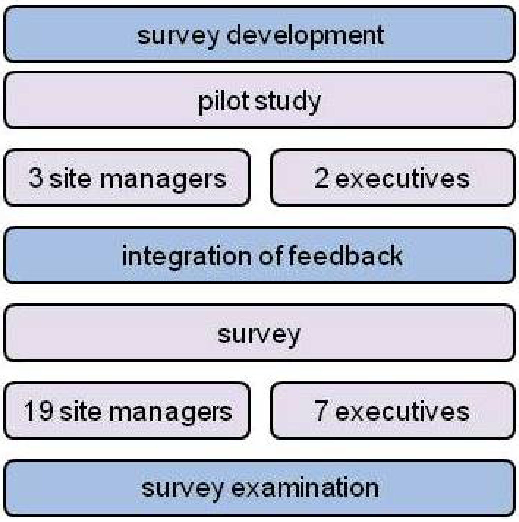


Figure 3: Procedure of the survey

Of the 26 mailed survey forms all were returned. 7 surveys were done by executives, 19 by site managers. All of the respondents were male, and the average age was 39 years (executives 44; site managers 34). All of the respondents had experience of more than five years. Figure 4 shows the assessed percentages of each activity to the total time.

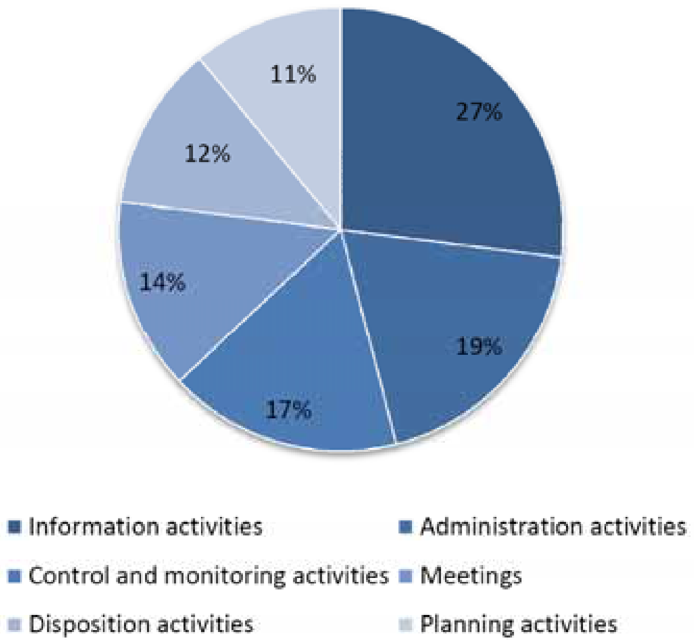


Figure 4: Time components of the activities of site managers (survey)

Information activity (27%) was estimated as the task which is performed the most. For the respondents was communication with external and internal parties was a big time factor. For example there are almost daily technical conversations with the foremen or coordination talks with the representatives of the client. An Interesting fact is that disposition activities (12%) as well as planing activities (11%) are not highly rated. According to respondents, these activities will be especially taken by foremen and technicians.

Interviews

The second step of the investigation included interviews, in which 22 of the 26 participants were consulted. The aim of these interviews was to find out which specific tasks of site managers and supervisors are being combined with the general activities. For this purpose a literature analysis was done in advance, in which the relevant German literature on construction management was studied. Thereby all tasks which were identified in the literature got included in a list. In total 68 individual tasks could be identified. Some of these could be grouped, so that the number was reduced to 55. The updated list was presented to the participants and they were first consulted whether these tasks are generally executed by site managers or not and further if there are tasks which are not on the list. Afterwards the participants were asked to assign these tasks to the main activities (example for assigned tasks to control and monitoring activities see Figure 5).

control and monitoring activities

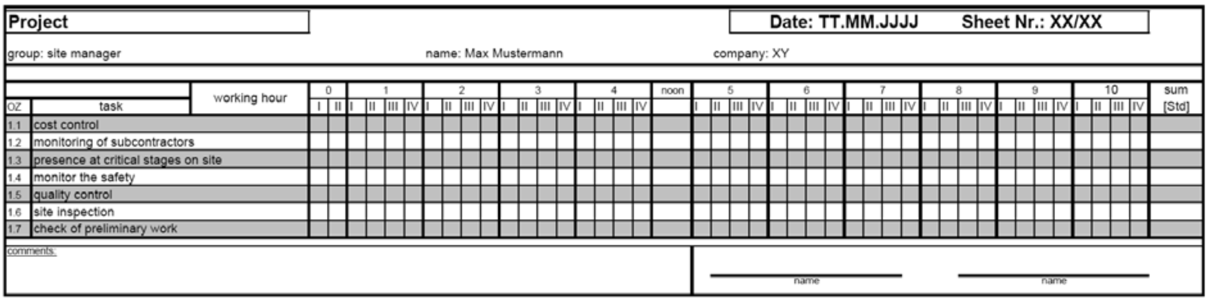
- cost control
- monitoring of subcontractors
- presence at critical stages on site
- monitor the safety
- *quality control*
- site inspection
- check of preliminary work

Figure 5: Specific tasks of control and monitoring activities

In this paper only tasks for the main construction period are presented. Others at the beginning and the end of the construction activity were also collected, but are not shown in the report. The result of the interviews showed that 31 individual tasks can occur during the work of site managers in the main construction period.

Site monitoring

The third step of the investigation was carried out directly on site. The results from the interviews and the survey were taken up again, as well as the participants. The 31 collected tasks were integrated in a time detection form (see Figure 6). This forms were filled out by the site managers. For every quarter of an hour they marked those tasks in the form which they had just executed. At the end of the work day, the sum of the consumed time was calculated for each task. Observations were made by external persons and compared with the notes of the site managers. Significant differences did not occur here.



Project | **Date: TT.MM.JJJJ** | **Sheet Nr.: XX/XX**

group: site manager | name: Max Mustermann | company: XY

		working hour	0	1	2	3	4	noon	5	6	7	8	9	10	sum
OZ	task		I II	I II III IV	I II III IV	I II III IV	I II III IV		I II III IV	I II III IV	I II III IV	I II III IV	I II III IV	I II III IV	[Std]
1.1	cost control														
1.2	monitoring of subcontractors														
1.3	presence at critical stages on site														
1.4	monitor the safety														
1.5	quality control														
1.6	site inspection														
1.7	check of preliminary work														

comments:

name | name

Figure 6: Part of the time detection form

The measurement of data by self-recording is categorized as a highly structured interview situation. For the determination of working times this analytical-experimental method is well applicable. The data gained is primarily evaluated by stochastical methods (Cichos, 2007).

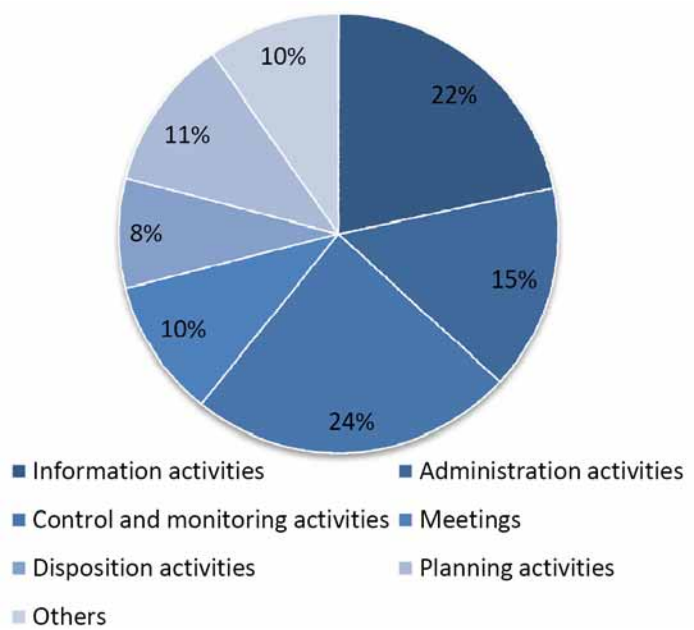


Figure 7: Time components of the activities of site managers (site monitoring)

So far, six sites and eight site managers were examined for at least two weeks in this study. Four to six other sites will follow. Overall, these have been 1327 hours of observation recorded until now. The five most important individual tasks were: site meetings (10.2%), site inspection (9.8%), internal communications (9.1%), cost planning/cost control (6.8%) and documentation (6.2%). In order to have a comparison with the survey, the 31 tasks have been reassigned to the six main activities (see Figure 7). Some tasks (travel times) as well as breaks have been grouped among others. The analysis was performed on a mean value calculation for each of the 31 tasks. They were illustrated by using boxplots, which describes the location and spread of a distribution, and gives indications of possible outliers. The boxplot in Figure 8 shows the average working hours used for documentation per week.

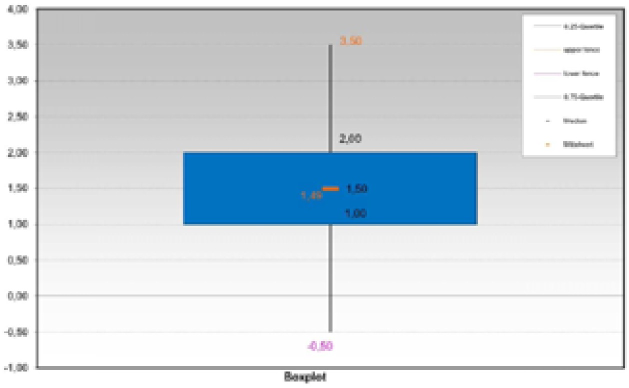


Figure 8: Boxplot of the task: documentation

The raised values have been subjected to a significance test (Bortz, Schuster, 2010). This is based on the sampling frequency, which means the larger the sample of each activity, the higher the significance. The results of this test show that, for seventeen tasks the probability of a deviation is between 1% and 7%, for seven tasks between 8% and 20% and for six over 21%. In general these are valid results, but further observations are needed. The comparison with the survey shows no major differences (Figure 9). The activity with the most time required is control and monitoring, compared to information activities at the survey. The studies show that good results can already be achieved with surveys. By carrying out observations on site they can be improved as well as new information can be included.

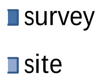


Figure 9: Comparison survey-site monitoring

5. Conclusion

The findings of the investigation can be used for the problems described in the introduction. As an example (point 1 of the Introduction) the developed task profile can be used specifically to coordinate education and training with site managers. For instance meetings have been identified as those sub-task, which occupy the most time of site managers. In construction companies trainings for the running of meetings as well as supporting communication and negotiation skills, are offered only in very few cases. However, in a meeting it is very important for site managers to represent their opinions and the view of the company properly.

The tasks and considerations of the construction management have one single purpose: that the construction is completed as smoothly as possible and unexpected events can be largely avoided. The prevention of possible “break-downs”, usually guarantees an economic handling. For this reason it is not surprising that the main weight and the largest amount of time is spent on information activities related to controlling and monitoring. A good site management team is characterized by the fact that they have, in addition to extensive knowledge and experience in the construction industry, negotiating skills, knowledge of human nature and leadership abilities. Site management is a very diverse and an interesting field of activity with many responsibilities.

6. Acknowledgements

The writers wish to acknowledge the assistance of the construction companies who took part in the development of the research on which this paper is based.

7. References

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Impediments to measuring construction site managers' performance

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Abstract

The work of site managers has been delineated as one of the toughest jobs in construction projects. Holding the role as middle manager, they have to bear concurrently the responsibility for strategy implementation, policy transference, planning and leadership work. Literature shows that site managers' performance is highly correlated with the overall success or failure of a project. Therefore, it is essential to measure the performance of construction site managers. This paper aims to highlight the conditions that impede the measurement of construction site managers' performance. Through a literature study, two major sets of problems are found: i) those that exist inherently in the performance measurement system of the industry and ii) those that are specific to construction site managers' performance measures. Because of these hurdles, the result of the measurement provides little room for continuous improvement, fails to evaluate leadership capability, and does not represent perspectives of different stakeholders. The findings should help to push scholars and construction actors towards developing a methodology for monitoring an individual performance in a construction organization.

Keywords: performance measurement, project management, project success, literature review

1. Introduction

The construction industry today has acknowledged the significant role of site managers. A study by Mustapha and Naoum (1998) affirmed that site managers are key persons in the construction process. They suggested that site managers' abilities highly influence the overall success or failure of projects. Furthermore, many subsequent studies developed from the idea of Mustapha and Naoum have examined the specific aspects that are subjected to the performance of site managers. Bossink (2004), for example, studied the correlation between innovation and leadership styles in construction projects. Styhre & Josephson (2006) and Bower & Gilbert (2007) highlighted the site managers' dilemma over strategic production objectives and daily administrative routines. Most of the studies have succeeded in emphasizing the importance of site managers and identifying factors that affect site managers' work. Those studies also indicate that changes in the site managers' performance could affect the project positively or negatively; thus, there is reason to monitor the site managers' performance. However, even though performance measurement must be carried out, only a few studies have addressed the methods for measuring the site managers' performance so far (Fraser & Zhu, 2008). The research on the measuring methodology has been given more attention since the 1990s, beginning with the studies by Mustapha (1990), Mustapha & Naoum (1998) and Fraser (1999). During that period, researchers focused on integrating characteristics needed to become an effective manager, laying the foundation for further studies. In the last decade, researchers have developed the list of characteristics to a thorough competency model which combines the list of competencies with project variables (Cheng *et al.* 2005; Ahadzie *et al.* 2008)

This paper reviews relevant literature and discusses conditions that impede the measurement of site managers' performance. The review is primarily based upon studies by Neely *et al.* (1995), Cox *et al.* (2003), Beatham *et al.* (2004), Mustapha (1990), Fraser (1999), Mustapha & Naoum (1998), Fraser & Zhu (2008), Cheng *et al.* (2005), Ahadzie *et al.* (2008) and Construction Excellence in Built Environment (2009). The literature study reveals two major sets of impediments when measuring site managers' performance: i) those that exist inherently in performance measurement systems used in the industry and ii) those that are specific to construction site managers' performance measures. The first set comprises existing measuring impediments regardless of construction actors, while the second set comprises impediments that are only applicable for site managers, thereby complementing the first one.

2. Inherent impediments in the performance measurement system of the construction industry

The measurement of performance has been discussed from a variety of perspectives. In several businesses, organizational performance was traditionally accounted for in financial terms such as profit and turnover (Beatham *et al.* 2004). However, in order to cope with rapid changes, especially in new technologies, tougher market competition, and stricter clients' requirements, Kaplan and Norton (1992) argued that evaluating performance from only the financial perspective was obsolete, and managers should assess the issue from several different perspectives simultaneously. The perception of Kaplan and Norton was not totally new at the time when their paper was first published. Kotler

(1984) had previously appraised performance in terms of effectiveness and efficiency from the marketing point of view. Effectiveness was explained metaphorically as “doing the *right* things”, while efficiency was regarded as “do things *right*”. Since those dimensions of performance were discussed in the marketing realm, they predominantly reflected the perception of customers or end users. Therefore, the measurement of effectiveness and efficiency in the construction industry needed to be adapted to fit the context in which a variety of stakeholders such as clients, contractors, suppliers, etc., are involved.

Neely *et al.* (1995, p. 2) clarified the concept of performance measurement by defining it as “the process of quantifying the efficiency and effectiveness of action”, a performance measure as “a metric used to quantify the efficiency and/or effectiveness of an action”, and a performance measurement system as “a set of metrics used to quantify both efficiency and effectiveness of actions”. In other words, a performance measurement system is an entity consisting of a multitude of “individual performance measures”, or “performance measures”. The authors attempted to gather previous key studies on performance measurement and categorize the dimensions of performance measures into four aspects: time, cost, quality and flexibility, see Table 1.

Table 1: The multiple dimensions of quality, time, cost and flexibility (Neely *et al.* 1995, p. 4)

Quality	*Time*	*Flexibility*	*Cost*
Performance	*Manufacturing*	*Material quality*	*Manufacturing cost*
Features	*Rate of production introduction*	*Output quality*	*Value added*
Reliability	*Deliver lead time*	*New product*	*Selling price*
Conformance	*Due date performance*	*Modify product*	*Running cost*
Technical durability	*Frequency of delivery*	*Deliverability*	*Service cost*
Serviceability		*Volume*	
Aesthetics		*Mix*	
Perceived quality		*Resource mix*	
Humanity			
Value			

Although such an approach to performance measurement allows construction actors to examine several angles simultaneously, it lacks specificity. The main problem with these indicators is that they are so general and can be interpreted differently, thereby causing confusion. For example, the term “value” under the “quality” dimension, without any careful explanation, could easily be misunderstood. In the projects which employ “value engineering”, value is defined as the amount of money spent on the projects (Benstin *et al.* 2011). “Value” in “value-added activities”, on the other hand, can be explained from various perspectives such as economical, psychological, and sociological views (Fine *et al.* 2010). Moreover, a random-selected indicator from Table 1 may be appropriate neither for performance measurement in the construction context nor site managers’ performance. The indicator might be interpreted differently not only from its original indication but also regarding implementation. "Selling price" is an example of such an inappropriate indicator. To ameliorate these problems, an industry-oriented measuring system encompassing a multitude of performance measures has been designed in order to monitor and appraise the performance of the construction actors.

Current performance measures for the construction industry have relied on the quantitative and qualitative performance indicators that have emerged since the 1980s (Cox *et al.* 2003). Cox *et al.* (2003) listed ten prominent quantitative indicators and four qualitative indicators, see Table 2.

Table 2: The fundamental performance indicators in the construction industry (Cox et al., 2003)

Quantitative performance indicators	*Qualitative performance indicators*
Units/Man-hour	*Safety*
$/unit	*Turnover*
Cost	*Absenteeism*
On-time completion	*Motivation*
Resource consumption	
Quality control/Rework	
Percent complete	
Earned Man-hours	
Lost time accounting	
Punch list	

Initially, these indicators were studied independently with universal assumptions applied for all organizations. However, the obstacles met by one organization differ from those met by another, causing the purposes of measurement to be different from one organization to another; these obstacles are usually complicated matters, requiring multiple measures. Therefore, an individual construction firm or a group of cooperating firms need to design their own set of performance measures.

Beatham *et al.* (2004) summarized seven sets of performance measures, which were established by leading organizations in the UK construction industry. They are, namely, Construction Best Practice Program (CBPP) KPIs, Design Quality Indicators (DQI), Construction Industry Research and Information Association (CIRIA) KPIs, MCG Benchmarking Club KPIs, Association of Consultant Engineers (ACE) KPIs, Respect for People (RFP) KPIs and Satisfaction of Service (SoS) KPIs. Unfortunately, with these diversified groups of KPIs, construction actors failed to reach a consensus on choosing a reference point. To solve the problem, the UK government, represented by BIS-Department for Business Innovation and Skills (formerly known as BERR-Department for Business, Enterprise, and Regulatory Reform), co-operated with construction organizations to provide a KPI index system for the industry. A recent regular report from Construction Excellence, the key partner of BERR since 1999, listed three general groups of KPIs: Economic KPIs, Respect for People KPIs, and Environmental KPIs. Each group includes different specialist KPIs depending on whether the measuring object is M&E contractors, consultants, or products (Construction Execellence in Built Environment, 2009).

Presenting a different position than Neely *et al.* (1995) on the classification of performance measures, Beatham *et al.* (2004) divided KPIs into three categories: lagging measures, leading measures, and perception measures. "Lagging measures are used to assess completed performance's results" while leading measures reflect performance "whose results are used either to predict future performance of the activity being measured and present the opportunity to change practice accordingly, or to enable future decisions to be made on future associated activities based on the outcome of previous activities" (Beatham *et al.* 2004, p. 14). Perception measures, on the other hand, are versatile. They can be lagging or leading measures depending on which stage of the process the measures are used. "Client satisfaction" exemplifies this type of measure. If "client satisfaction" is measured at the end of the project, the results reveal only the attitude of clients, which cannot be changed. In this case, it is a lagging measure. Alternatively, if "client satisfaction" is measured at various stages of a project, the result is not pertinent to the overall client attitude at the end of the project. In other words, it can be used as a reference to maintain or improve the result in future actions. So, the measure is considered a leading measure. According to Beatham *et al.* (2004), perception measures require immediate feedback on past performance. For this reason, perception measures, if overused, may create a culture wherein the employees and clients always want to have feedback. It is still controversial whether the culture is not constructive.

Because the construction industry has not classified measures as "lagging", "leading", and "perception", several problems have emerged (Beatham *et al.* 2004). Three fundamental problems are presented in this section. First, most of KPIs so far are lagging measures which allow little room for changes. The focus on lagging measures is a severe problem in the construction industry where many projects can be considered as rather unique. Because of the uniqueness of projects, the measures based on outcomes of past projects probably become useless when the results are used to improve future projects. In fact, the only indicator that is regularly measured during the process of a construction project is safety (Beatham *et al.* 2004). Ergo, there is a great need for using leading measures that detect potential problems that have consequences in later phases of the process. The second problem is a result of the benchmarking purposes of the KPIs. Since the majority of KPIs are lagging measures, they do not support continuous improvement; rather, they serve as cross-industry benchmarks. However, due to the uniqueness of the projects in terms of, for example, differences in procurement routes and uncertainty in data, the suitability of the common benchmarks for all construction projects is doubtful. As a result, the KPIs have been employed as a marketing tool rather than an improvement tool. Last but not least, the KPIs are incapable of covering all the criteria that are necessary for business excellence. Beatham *et al.* (2004) pointed out that all the indicators of CBPP, MCG, CIRIA, SoS, RFP, DQI, ACE failed to be associated with criterion 1 (leadership) and criterion 2 (policy and strategy) in the European Foundation of Quality Management (EFQM) Excellence Model. Literature portrayed site managers' work as the toughest and hardest jobs in the construction process whence site managers, playing the middle-manager role, are concurrently responsible for strategy formulation (King, Fowler, & Zeithaml, 2001), policy transfer between top-management and subordinate workers (Linstead & Thomas, 2002), and leadership work (Fraser, 2000). Ergo, the discussed KPIs, which do not include "leadership", "policy and strategy", are unable to facilitate the performance measures of the construction site manager. In respect of site managers' performance, its measurement is encumbered by all three aforementioned impediments. However, since the first and second problem can be rectified easily by adjusting lagging measures to become leading measures, the third problem needs special attention, which requires studies specific to construction site managers.

3. Impediments to measuring construction site managers' performance

Styhre and Josephson (2006), in their study on site managers' working experience, found that the literature on middle managers in general and site managers in particular has been minimal. As a result, the knowledge of site managers' performance is very limited. Among the few who have studied site managers' performance are Mustapha (1990), Mustafa and Naoum (1998) and Fraser (1999). Their research has focused particularly on the effectiveness of site managers. Initially, Mustapha (1990) devised a list consisting of 62 competence elements for effective site managers, in which a competence element was referred to as "an underlying characteristic of a person which results in effective and/or superior performance in a job" (Fraser, 1999, p. 3). The underlying characteristic may not only be considered skills but also body of knowledge, motives, traits, or social roles (Fraser, 1999). The list includes, for example, honesty, managing interpersonal conflict, and managing contractual conflict. From Mustapha's competence list, Fraser (1999) developed a non-results-based effectiveness index in order to measure the performance of site managers. The index, which is a modified version of Mustapha's list, comprised 52 competence elements produced by a focus group of 15 senior head-office-based managers. Fraser's index was and later used to survey the attitude of stakeholders regarding their perception of an effective site manager and the importance of the elements. Both Mustapha (1990) and Fraser (1999) believe that effectiveness is a result of utilizing high levels of personal competence and also answer the question of what constitutes the performance of site managers. Thus they shed light on the performance of construction site managers.

After their list of competence elements was published, Mustapha and Naoum (1998) continued to examine the factors that influence the effectiveness of site managers. They canvassed personal attributes, such as management style, qualification, and job-related variables, such as team relationship, job satisfaction, as the most essential factors among all the considered variables. In other words, according to their findings, a high-performing site manager is likely to have a team-oriented management style, highly qualifying education and a high level of job satisfaction. In addition, the results also raised a question of the extent to which the project variables, e.g. building type, project complexity, project size, and organizational variables, e.g. company structure, level of authority given to site manager, impact the site managers' effectiveness. Later studies by Cheng *et al.* (2005) and Ahadzie *et al.* (2008) attempted to take those variables into account and develop a comprehensive competency-based multidimensional model. These studies managed to build up a rigorous competency profile for site managers by specifying their expected skills and behaviors in construction projects. Although the competency profile was able to clarify the issues raised by Mustapha and Naoum (1998), it failed to present the viewpoints of different stakeholders. Ergo, there was still a substantial need to explore how the perceptions of site managers' effectiveness vary across stakeholders.

This research question remained unanswered until Fraser and Zhu (2008) researched the significance of 52 competence elements from site managers' effectiveness index (Fraser, 1999), which were accounted for by eight major groups of stakeholders. These groups are, namely, civil engineer, architect, subcontractor, quantity surveyor, services engineer, client's representative, assistant manager (immediate subordinate), and contracts manager (immediate superior). A total of 329 participants took part in the questionnaire study. Their answers revealed that site managers, their superiors and subordinates (Fraser and Zhu labeled these three groups together "internal stakeholders") mostly agreed about the necessary competence elements for an effective site manager, while those external stakeholders (the five remaining groups) disagreed with site managers. The disagreements varied from ten elements (in the case of civil engineers) to three elements (in the case of subcontractors and surveyors). Additionally, the study's result also showed "high-performing" managers emphasized honesty, ethical behaviors, management of health and safety, which contrasts with "low-performing" managers' choices favoring technical understanding. In the light of stakeholder theory, it would appear that the perceptions of the actors in construction projects are very discrepant. A manager may be effective in his or her superior's eyes, but may be out of tune with the external stakeholders. As a consequence, measuring site managers' performance must be recognized as more arduous and complicated.

As far as the literature shows, no study has taken the concept of efficiency into account when examining the site managers' performance. Because efficiency and effectiveness coalesce into the concept of performance (Kotler, 1984), studying efficiency is vital to performance improvement. Although Mustapha & Naoum (1998) enumerated the *right things* for site managers to pursue, then Fraser *et al*. (1999; 2008) elaborated on their priority and significance from various perspectives, none of the studies delineated the *methods* to accomplish those right things. For example, among 52 competence elements listed in the index for site managers (Fraser, 1999), "honesty", "managing interpersonal conflict", and "managing contractual conflict" are perceived to be the most important. Yet, "to which extent a site manager should be honest?" or "what a site manager should do to manage interpersonal and contractual conflict?" are still research questions with no well-documented answer. Moreover, even if a site manager has the answers, executing them accordingly would be subject to numerous factors such as culture, legal regulations, work situations, personal experience and so forth. Since these factors vary greatly, this paper argues that a one-best-way method for all cases is impossible. Apropos studying the construction site manager's efficiency, it also requires researchers to integrate knowledge from beyond the realm of construction, for example, social sciences (e.g. psychology) and manufacturing principles (e.g. lean production). While lean principles such as continuous improvement and employee involvement have inspired construction managers for over four decades, the construction industry have started only recently to pay great attention to social aspects. The contemporary research is scrutinizing human psychology, i.e. motivation, emotion, thinking, striving to understand managers' decisions and behaviors as well as enhance coordination and communication. A few famous studies of mangers' thinking in general are "How senior managers think" (Isenberg, 1984), "Humble decision making" (Etzioni, 1989), and "The hidden traps in decision making" (Hammond *et al.* 1998). These studies can be the foundation for further studies about construction site managers' decision making. When construction site managers' thinking and behaviors are better understood, construction site managers' performance measurement can be expected to transcend the current boundary to reach the two remaining criteria in EFQM model, "leadership" and "policy & strategy".

4. Conclusion

This literature review summarizes four generic impediments to measuring site managers' performance that exist in the construction industry and two impediments specific to the site manager role. The first set includes lacking specificity, lagging measures, misuses of KPIs and no indicator of leadership and strategy competency. Among the generic problems, lacking specificity has been discussed thoroughly in early research. In order to avoid misinterpretation, the construction actors, with assistance from governments, have tried to create a standardized KPIs system. UK construction industry has successfully been one of the leading protagonists. In spite of the consensus that the KPIs system alleviates the problem, it has been still a great challenge to measure individual performance since most of the KPIs are lagging measures and overused for marketing purposes. These two problems restrict construction actors in general and site managers in particular from continuously improving their performance. Additionally, the generic KPIs are unable to evaluate site managers exhaustively. No generic KPI has as yet reflected site managers' leadership and strategy skills. Therefore, it is necessary to conduct more specific studies. However, research about site managers' performance is scanty. In fact, a few attempts have been made to design the best way to behave for site managers, but they have always been hindered by the second set of problems. This second set encompasses deficiencies in efficiency measurement and differences in stakeholders' perspectives. That is to say, even if site managers know the right things that they should do, they may not know how to do them properly and their performance's appraisal can vary greatly, depending on the stakeholders' point of views.

The ultimate purpose of any measure is to stimulate actions for improvement or change. Without succeeding actions, the numbers resulting from performance measures are almost meaningless, and the measures become a complete waste of time and money (Bourne *et al.* 2000). Hence, an organization should analyze the measurement initiatives and plan for the later phases in advance. Many organizations stop at analysis and do not progress to implement the performance measures. Bourne *et al.* (2002) enumerated seven constraints leading to early cancellation of measurement process: i) over resource consumption (time, money, and effort), ii) perceived bad personal consequences, iii) perceived insufficient benefits, iv) insufficient top-management commitment, v) higher authority's influence, vi) data inaccessibility, and vii) problems related to applying the measures. By correlating these constraints with the site managers' activities, this paper hypothesizes that "perceived bad personal consequences" and "perceived insufficient benefits" are the greatest impediments to the site managers' performance measures' implementation. Further studies should consequently aim at these areas.

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Organizing production for speed and safety: Lessons from a multi-story concrete building

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Abstract

This case study analyzes the production practices used during the construction of the concrete structure of a 10-story commercial building. The structural concrete operation was under high schedule pressure, with one floor completed every week. The study focuses on the work organization and the work management practices that the concrete supervisors used to meet the schedule goals with high productivity and exceptional safety. The authors performed extensive field observations—over 60 hours during the 10 weeks of the concrete operation, interviewed the supervisor and work crews, and analyzed the individual activities. The paper first describes the project characteristics and demands, the work activities and the work sequence. Then, it discusses the production control strategies the supervisors used in order to establish a fast and reliable pace. Such strategies included: using crews specialized in "product lines" (horizontal and vertical concrete elements), reducing product variability (the number of different concrete mix designs), standardizing the work sequence, emphasizing manpower reliability and predictability (e.g., minimizing absenteeism), reducing task complexity and time pressures (by simplifying and decoupling tasks), preventing errors, exploiting the limited resources (in this case the crane), etc. The discussion of the practices indicates that the supervisor's emphasis was on maximizing the reliability of the production process by reducing variability and by preventing errors rather than maximizing productivity. As a result, their work practices "converged" to create a highly reliable work system that resulted in high speed as well as with high productivity and safety.

Keywords: Concrete construction, Production practices, High Reliability, Task Demands, Safety

1. Introduction

Construction operations are subject to multiple demands for speed, cost, productivity, quality and safety. The high production pressures and workload, combined with the dynamic, hazardous and often unpredictable construction tasks and environment, increase the likelihood of errors and accidents. Significant safety effort is invested into preventing accidents. Despite such efforts, in the U.S. the frequency and severity of construction accidents continue to be a significant economic and social problem. In 2008, the private construction industry employed 5.7% of all employees and had 19.5% of the fatal work injuries (Bureau of Labor Statistics 2011).

Construction work involves a large number of work processes that need to adapt to the project-specific requirements and context. The loosely defined construction work processes allow the work crews many degrees of freedom in how they organize and coordinate the work. As a result, construction crew practices determine largely how the actual work is organized and coordinated (such as task allocation, sequencing, workload, pace, work coordination, teamwork, etc.) and consequently they shape the work situations that the workers face. Hence, the organization of the work and the work practices are important for both productivity as well as safety. With the continuous pressures for speed, productivity and competitiveness, an important challenge for construction researchers and practitioners is to develop work systems—that is, work processes and work teams that are simultaneously highly productive and highly reliable and can function safely and effectively in the dynamic and complex conditions of construction projects.

This case study is part of an on-going research effort that aims at identifying those work practices that achieve both high production and high safety (Mitropoulos et al 2009, Memarian & Mitropoulos 2010, Mitropoulos, & Guillama 2010). The goal is to identify which work practices increase speed and productivity, while at the same time reduce the likelihood of accidents, and how. To accomplish this, the research investigates the work practices of 'high-reliability' field supervisors and crews. The term High Reliability Organizations (HROs) has been used in organizational research to describe organizations such as aircraft carriers, nuclear power plants and wildland firefighting crews who function extremely reliably under very uncertain and hazardous environments. In the context of this research, 'high reliability crews' are defined as those construction crews and supervisors who consistently achieve very high levels of production and safety, even during challenging project conditions.

This case study analyzes the work organization and production practices of a high reliability field supervisor in a concrete construction firm. The work practices of the exceptional supervisor were observed and documented during the construction of a 10-story concrete frame for a commercial building with a very aggressive schedule. This project provided the opportunity to investigate how an exceptional supervisor organized and managed the work to achieve both production and safety under high schedule pressures.

2. Background

Schedule pressures are considered an important factor that increases the likelihood of accidents. Hinze and Parker (1978) found that production pressures and crew competition are related to more injuries, and suggested that job practices are more important than safety policies in preventing accidents. The negative effects of schedule pressure include: working out of sequence, generating work defects, cutting corners, and losing the motivation to work (Nepal et al 2006). Safety research has recognized that production pressures can create work overload (Karasek & Theorell 1990; Parker & Sprigg 1999). Excessive demands overwhelm the resources available to meet demands and harm job performance (Bakker et al 2005, Brown et al 2005). Furthermore, production pressures can arise from unclear or conflicting messages from management generate role ambiguity that in turn reduces work performance and weakens safety (Hemingway & Smith, 1999).

Overtime is typically a consequence of production pressures and has been related to reduced productivity and increased accidents (Hanna et.al 2005). Shift work has also been found to have a significant effect on fatigue. Folkard & Tucker (2003) found strong evidence that both productivity and safety may be compromised at night. A review of the research on piece rates has found that in most situations piece rates have a negative effect on safety (Johansson et al 2010).

The above discussion highlights the effect of work organization on safety. Based on a cognitive perspective, Mitropoulos & Cupido (2009) proposed that construction safety is considered an emergent property of the production system. From this perspective, the work practices and the team processes of the crew shape the task demands of the situations that the workers face, and the potential for errors and accidents (Mitropoulos & Guillama 2010). Along this research direction, this study investigates the production processes that high reliability supervisors use to achieve both high speed (accelerated project schedule) and safety.

Studies of high reliability foremen in framing and masonry (Mitropoulos & Cupido 2009, Memarian & Mitropoulos 2010) found that production practices of high-reliability foremen were shaped by a clear “guiding principle,” which is a strong focus on avoiding errors and rework. These foremen used a set of strategies that support this principle, including actions to prevent disruptions, controlling the production pressures, mitigating the physical and cognitive task demands for the workers, matching skills with task demands, and carefully preparing and coordinating the high demand tasks.

3. Methodology

This investigation used the case study methodology, which provides better opportunity to perform an in-depth examination of the production practices. The selection of the case to study was a critical concern, as the goal was to investigate the practices of a high reliability supervisor in concrete work. After contacting several contractors, a large concrete contractor who operates in several states agreed to participate in the study and to provide access to data and jobsites. To identify any ‘high reliability’ field supervisors, the management provided data on the supervisors’ productivity and safety performance. The production performance of the field supervisors was assessed over the previous three years. The operations manager evaluated each supervisor using a 10-point scale (where 1 is the lowest and 10 is the highest) according to the following criteria: (1) difficulty of the projects the supervisors managed, (2) production performance, and (3) quality performance. The supervisors' safety performance was assessed by calculating each supervisor's incident rate during the three-year period. To calculate the incident rate the company provided information on (1) the labor hours each supervisor managed; (2) the number of incidents that occurred under their supervision; and (3) the total cost of incidents that occurred under their supervision (using the workers' compensation costs as indicator). The supervisor who was selected for the study was assessed as follows: project difficulty 10, production performance 9, and quality performance 9. Over the previous three years he had one first aid incident.

The data collection process was carried out over a two-month period, and included multiple interviews and direct observations. Interviews with the supervisor focused on the organization and sequencing of the work, the selection of work methods, the management of resources, the production goals and pressures, the safety practices, etc. Interviews included pre-structured and open-ended questions. Furthermore, the authors conducted extensive close observations in order to understand the details of the operation and to cross-examine the data from interviews.

4. Project Description

The project in this case study was a 10-story office building, with a cast-in-place (CIP) concrete frame and post-tensioned concrete slab. Each floor was about 27,000 Square Feet (SF). The floor layout was almost identical from the first to the last floor with minor changes at the second and ninth floors. There were 28 columns and the elevator shaft on each floor. Columns were of two different sizes (24"× 24" and 28"×28") and their dimensions did not change from the first to the last floor. The slab around the elevator shaft was the most critical point that required the highest level of accuracy. According to the concrete crew superintendent, the design complexity of the project was low, the deck forms were easy to set up. Furthermore, the repetitive layout created a repetitive work process. The main challenge was the very aggressive schedule. The structural CIP frame was to complete the building in 10 weeks (one floor per week). Furthermore, construction was performed during the summer with the temperature constantly over 110 °F. This was another concern for the contractor in terms of safety risk and productivity loss. The jobsite was congested and different trades were working in each other's proximity.

5. Work Organization

The concrete supervisor divided the concrete work into two major operations: horizontal (deck) and vertical (walls and columns) concrete work, and assigned a specialized crew to each operation. To shorten the schedule, a night crew was also used that continued the work of the deck and vertical crews, as needed. The contractor for the reinforcing steel was a subcontractor to the concrete contractor. Overall, three crews were working in parallel during the day time (horizontal, vertical and rebar crews) and the night crew was working from 8 p.m. to 6 a.m. Each floor was divided into two halves, and the deck and vertical crews were working on different halves in parallel. A concrete placing crew poured and finished the concrete slabs. The vertical crew poured the columns and walls themselves.

The work schedule was six days a week (Monday through Saturday), 10 hours a day. The supervisor established a standardized repetitive work process. For each section A (the first half of the slab) the deck was poured on Thursdays at 9:00 PM, and the walls and columns on Friday on at 1:00 PM. The deck for section B was poured on Mondays at 9:00 PM (section B), and the walls and columns on Tuesday at 1:00 PM.

5.1 Concrete Deck Operation

The concrete deck crew consisted of 18-20 members including one superintendent, one foreman, two leadmen carpenters, 10-12 carpenters, one grader, and three laborers. The supervisor who planned the entire operation was also in charge of the concrete deck operation. On this project, the Elevated Aluminum Tables system was used for the deck formwork. Tables were adjustable to be used at different heights and had folding wings to cover perimeter of the column. The concrete deck crew performed the following activities:

- **Set up deck forms.** When a deck was stripped, the crane would lifted the tables to the next level and place them at the correct position. It took a 10-hour day to move and set up the 24 tables for each half floor. The setting crew consisted of three carpenters. Once the tables were set up, a grader would start grading (leveling) them.

- **Fill tables.** After the tables were set, two carpenters would fill the gap between the table wings and columns using 2×4 and plywood

- **Install "Z metal".** Z shaped plates were used to form the sides of deep concrete beams. Z metal is easy to install (nailed down) and either carpenters or laborers can install it.

- **Set edge forms.** Plywood and 2×4 were used to form the edge of the slab. This activity was done by two carpenters.

- **Install steel embeds.** There were 250 pieces of embed for each half a floor, and the installation was done by three carpenters.

- **Set shoring.** Shores were installed at every six feet. The project used the quick-pop adjustable aluminum shores. The activity was performed by three laborers.

- **Clean the deck and oil the forms.** This tedious task was the last task before concrete placement.

- **Pour concrete.** A concrete placing crew poured concrete when the formwork was completed.

- **Strip & fly tables.** When the concrete was adequately cured, the crew striped the edge forms and removed the shoring. Then the tables were stripped, lowered on a wheel-cart, pushed out, shackled, and rigged to the next floor.

- **Set reshores.** After the tables were removed, the crew repositioned the shores under the deck.

5.2 Vertical Concrete Operation

The vertical concrete crew consisted of nine members—one field supervisor, one carpenter foreman, five carpenters, and two apprentices. The supervisor was in charge of management tasks and the foreman was closely monitoring the crew's performance and participating in the wall form setting activity. The carpenters' tasks included installing embeds, installing rebar chairs, setting and plumbing wall and column formworks. Apprentices mainly performed support tasks including cleaning and oiling forms and ties, housekeeping, material handling, etc. The vertical work crew performed the following activities:

- **Install embeds and spreaders.** Embeds are steel plates installed in the walls before pouring. Spreaders (rebar chairs) are accessories installed on the rebar cage to maintain the clearance between form and rebar. These two activities were done by four workers.

- **Prepare the forms & ties.** This activity was to clean and oil the wall panels and column forms. The whole activity was done by four workers. One worker was specifically responsible to check form ties and fix defective ties.

- **Set the inside walls forms.** The wall forms were formed by inside and outside formworks. To raise the inside forms, the crew used rails that were set up on the sides of the wall.

- **Set the outside forms.** Using the crane, the crew set up the outside wall and column forms. The whole crew (eight workers) was involved in this activity. According to the supervisor, flying and setting up the wall forms was the most critical activity of the vertical crew because of high accuracy requirements, and the risk of being struck by flying panels.

- **Plumb and square inner core walls**. This activity was to check the accuracy and alignment of formworks. This activity was done by four workers.

- **Pour walls and columns.** The whole crew (8 workers) participated in this activity that was performed in 4-hours.

5.3 Night Shift

The night crew consisted of six members including the night superintendent. The night crew performed activities for both day crews including raising interior core wall forms, stripping wall and column forms, lowering tables, installing Z metal and edge forms, and help for pouring deck concrete. To facilitate the night crews' work, the day crews made the following work preparations: (1) set up lights at proper spots, (2) get generator ready, (3) make sure the crew has all the materials needed, and (4) provide a clear description of what have been done during the day shift and what have been left to be done by the night crew. Early miscommunications were addressed and resolved by the crew supervisors. For example, the sequence of stripping and stacking the wall forms had to be clarified as it affected the speed of setting the forms on the next floor.

5.4 Rebar Crew

Rebar work was sub-contracted to another crew. Their work included making wall and column rebar cages, setting and fixing slab rebar, and fixing post-tension cables. The rebar crew was sharing the crane with concrete crews during the day shift. This crew had its own supervisor who was coordinating their work with the concrete crew supervisors.

6. Work Organization and Production Practices

The exceptional supervisor developed the work plan for the entire operation, and was in charge of the deck crew. This was the crew with the greatest production pressure. This section examines the work practices of the deck crew supervisor in order to meet the aggressive schedule

6.1 Standardized Work Cycles

The work cycle for each floor was the same and everybody in the crew knew when to do what. The crew had a clear work plan which specified when, where, who, and how to do the work. The supervisors of deck and vertical work crews established a timetable specifying what time each task had to be finished. Close coordination between crew supervisors of concrete, rebar, and night crews helped them update their work plan and help each other to accelerate the work, if some crew had fallen behind the schedule.

6.2 Method Selection

To meet the schedule requirements, the management and the supervisor selected to use Elevated Aluminum tables for the deck formwork, Z metals for the beam side forms, quick-pop aluminum shoring to support deck formwork, and Logik forms for vertical components. The shared characteristic of these methods was “transferring the assembly phase” from the jobsite to the shop. All these components were delivered to the jobsite preassembled and concrete crews were to a large extent installers. Thus, using these methods reduced the need for measurement, cutting, and assembling wood material on site, thus reducing the time, the potential for errors and rework. When the contractor faced some cost-speed trade-offs, but they decided in the favor of speed.

6.3 Crew Size, Selection and Policies

The critical concern of the supervisor was to meet the timetable, not to maximize productivity. As a result he sized the crew to reliably meet the goals, rather than to increase productivity at the risk of missing a milestone. The size of the crew increased from the original estimate to account for the requirements of the work plan and for reduced productivity due to heat. The deck foreman was another resource "buffer," as he was not only assigning the work, but also helping where needed. The crew members had clear instructions not to stop their work to help someone with a production problem, but to bring these problems to the foreman.

Crew members were selected based on two key criteria: (1) Capability, and (2) Reliability. As the supervisor explained, he selected workers who (1) Know what they are doing, and do not need much instruction; (2) Know the sequence of the work; (3) "Stay ahead of their task" and prepare for the work some steps ahead without telling them. Absenteeism was a major concern as it would create problems at meeting the milestones. The supervisor had a zero tolerance policy on absenteeism, which he explained at the time of hiring. The supervisor considered unjustified absenteeism as "*steeling other workers' time, which is not fair.*" As a result, he had just two occasions when a worker was absent over the life of project. The supervisor would not tolerate unprofessional behaviors and lack of personal tools in his crew.

Specialization was used for the tasks that required high accuracy: (1) The most skilled carpenters were assigned to the areas where higher accuracy of the edge form was required. (2) The leadman with strong construction engineering background was assigned to perform the slab and embeds layout. To prevent errors and omissions in important activities (layout, embeds, etc.) the supervisor established extensive checking requirements. Task rotation was another important element of the work organization, as the supervisor wanted to rotate the carpenters doing the heavier tasks. Furthermore, half the crew had Wednesday off—this was the crew members who were doing the heavier work on Monday and Thursday.

6.4 Task Simplification / Standardization

The deck supervisor found several opportunities to simplify and decouple activites. (1) He designed the configuration of the aluminum tables for ease of installation. As the supervisor explained he considered not only the number of tables, but the overall difficulty for moving them. For example, he would use two smaller tables instead of a large one, if that would make the work overall easier. (2) The tables were numbered so that the crew knew exactly where each table should be located. (3) The crew pre-marked the aluminum table legs at the appropriate heights to speed up installation and minimize potential mistakes. (4) The workers setting the tables used rubber mallets that deliver a softer blow and reduce the workers' discomfort. (5) The carpenters used screws for the edge forms instead of nails. The screws can be removed easier with less damage to the form. (6) While the dimensions of columns remained the same along all floors, the concrete mix design was different. To reduce the complexity of wall / column pours, the vertical crew reduced the number of concrete mixes from four to two. This modification was made after the engineers' approval.

6.5 Critical Resources

With the overlapping of the work activities, three crews were working at different areas of the deck every day. There was one tower-crane on the job, and all crews were dependent on that crane for their heavy lifts. This made the crane the bottleneck resource. In order to provide sufficient access to the crane and avoid conflicts, the crew supervisors developed a detailed crane schedule. Each crew was the primary user of the crane during their "busy" days. For instance, Mondays and Thursdays were the busiest days for the deck crew; during these days they had full access to crane, while the other crews had limited access. The limited access to the crane forced the crews to find ways to make the best use of the crane's time, and minimize their lifts. This required extensive preparation and detailed planning for the lifts, to make sure that they have everything they need. During the early stages of construction, other resources also turned out to be critical. Some simple materials like 2×4 and straps to bundle materials for lift were shared by all crews and sometimes they were taking each other's material, which created some delays.

7. Safety Hazards and Practices

The project had in place a strong safety program, with extensive safety planning, training, and inspections. Every morning, the supervisor would discuss the safety hazards of workers' immediate tasks. His general strategy was to repeat the safety requirements until they become "second nature" for the workers. The three most important safety concerns for the concrete crews were: falls, crane operations and heat sickness /dehydration. To prevent falls, the contra tor enforced a 100% tie off policy. To prevent dehydration (1) the contractors provided extra water, (2) rotated workers to task in the sun, and (3) he taught the symptoms of dehydration to his crew and asked them to monitor each other's wellness. Furthermore, the work schedule only required half the crew on Wednesdays. This provided some additional rest to those who performed the hardest tasks on Mondays and Thursdays.

8. Performance Outcome

The concrete crew successfully finished the project on schedule with no recordable injuries. With regards to work quality, the crew had few mistakes including: (1) on the fourth floor, the concrete deck was not level, and had about 1.5 inch "hump" at the mid-point of the slab. This issue created extra work for the vertical crew as they had to adjust their wall formworks to accommodate the levelness problem. (2) Both concrete deck and vertical work crews missed one embed, however the structural engineer found a solution that did not require adding the missing embeds.

9. Summary and Discussion

The production practices that contributed to successful performance under high production pressures, addressed the tasks, the work process and the resources. **At the task level**, the main strategies involved (1) reducing task complexity and task difficulty, (2) matching high demands with high capability. Such actions at the task level not only reduce the task duration and errors/rework, but reduce task variability and contribute to more reliable work flow. **At the work process level** two important strategies are identified: (1) increase reliability of the work flow, and (2) provide resources to manage the variability and performance problems. **At the resource level**, he exploited the resource bottleneck (crane) and provided additional resources where possible.

9.1 Reduce task complexity and task difficulty

At the task level, there was a systematic effort to reduce the task complexity and task difficulty. (1) Use Z metal. This method required fewer steps, less measuring and cutting, and less likelihood of mistakes). (2) Design the table layout to reduce the difficulty of flying them. (3) Decouple and error-proof tasks, so they can be performed ahead of time, and have less likelihood of errors during installation, such as the pre-marking of the table legs. (4) Use rubber mallets to reduce the effect of hammering on the workers.

9.2 Match high task demands with high capability

The selection of experienced crew members who understood the work process, required less supervision and could plan ahead of their task, was very important, as this operation was in "performance mode, not learning mode." Furthermore, the assignment of the more skilled crew members to the tasks with the higher accuracy requirements reduced the likelihood of errors and rework in critical areas where mistakes would be very detrimental to performance

9.3 Establish reliable work flow

Because of the schedule the operations were very tightly dependent—any significant disturbance in one operation would affect the entire work flow. Hence, the primary concern was to reliably meet the timetable, not to maximize productivity. The strategies to accomplish reliable work flow included: (1) standardizing the work process; (2) dividing the work to specialized crews (deck and walls); (3) providing adequate manpower; (4) emphasis on preventing absenteeism; (5) work rotation; (6) multiple checks to prevent rework; and (7) a clear policy for handling performance variability and problems. If a crew member had a problem or difficulty, the other crew members should not stop their work to help them. The deck foreman was responsible to handle the problem and re-assign workers as needed. The foreman knew the status of all tasks and he could assign resources so that other tasks would not be delayed.

9.4 Exploit bottleneck resources

Another factor essential for work flow reliability was the effective management of resource constraints. This was achieved with two strategies: (1) Provide additional resources where possible, as in the case of 2x4s and straps for crane lifts. (2) In the case of the crane, where a second crane could not be provided, the resource constraint was exploited by minimizing the number of lifts. This in turn, required detailed planning and preparation of the lifts.

10. Conclusion

This case study analyzed the work practices of a high-reliability field supervisor in concrete construction. The findings indicate that achieving high schedule and safety performance on accelerated projects requires emphasis on reliability, rather than on maximizing productivity. This requires production strategies that address the sources of variability at three levels: (1) At the task level, by reducing the task complexity and task demands. (2) At the work process level, extensive work preparation and coordination is needed to manage the dependencies between processes. (3) At the resource level, exploiting the limited resources and/or providing resource "buffers" reduces variability due to resources constraints. Together, the above strategies create high quality of work assignments, and a highly reliable workflow with low variability and very few errors and rework.

11. Acknowledgment

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Determining the Influence of the Work Area on Productivity for Floor Shuttering Works

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Abstract

Building projects are characterized by frequent disruptions to the construction process. Whether such disruptions have actually occurred, and the extent to which they influence the specific project, are key issues arising in construction management that often lead to disputes between clients and contractors. This paper is to specifically demonstrate the correlation between labour consumption rates and productivity from a construction management and economics point of view whilst determining the influence of process disruptions on labour consumption rates and productivity both quantitatively and qualitatively. The workspace or work area has a major influence on the achievable productivity when it comes to efficiently combining the individual production factors. Productivity losses occur if less than the area specifically required for the work is provided. As a result, the "average standard productivity" level cannot be reached. The parties involved in the project usually agree on this matter. There is, however, still uncertainty and disagreement regarding accurate figures pertaining to relevant minimum work areas and the magnitude of related influences. A situation analysis is performed in order to define and compare approaches to determining minimum work areas for reinforced concrete works. To gather current data, Graz University of Technology conducted an expert survey in Austria. 19 industry experts with extensive experience in costing, process planning, construction and claims management participated in this survey. A standardized questionnaire was used, and the experts were able to clarify issues with the interviewer. This approach enabled the experts to develop a better understanding of the survey, which was to result in more reliable data. The study aimed to determine the minimum work area for shuttering works and the influence on productivity if the work area provided was smaller than the minimum work area determined. This data is used to derive the minimum work area per worker [m²/worker] for flat floor shuttering works that is required to perform the work at the "standard" productivity level. Following the underrun of the minimum work area, labour consumption rates show an increase whose trend is shown as a function of the extent of work area reduction. These labour consumption rate increases can be used to calculate losses of productivity. Flat floors were specified in the expert survey. The required minimum work area and productivity loss data were taken from expert surveys for which an exploratory data analysis was performed. In construction practice, the findings of this study can be applied to costing, process planning, construction and claims management. The results can be used for two purposes: clients can verify the claims submitted by contractors, and contractors can substantiate their claims.

Keywords: loss of productivity, labour consumption rate, expert survey, shuttering works

1. Introduction

In construction practice, projects implemented without process disruptions are very rare. Workers require a minimum workspace to achieve a standard productivity level on the construction site. The amount of the minimum work area required for flat floor shuttering works and the change in productivity resulting from a minimum work area underrun often give rise to discussions and conflicts between the client and the contractor. There are only a few approaches outlined in the literature that can be used by the parties involved in the project to support their claims or to defend themselves against such claims. In this regard, the problem lies in the fact that some of these approaches were developed several decades ago, which is why they do not consider the streamlining effects and other advancements achieved in the meantime. In addition, the boundary conditions and methods applied to the development of these older approaches to describing productivity losses are mostly unknown. For one of the arguments frequently used to prove productivity losses that occur in construction practice, which is the reduction in the work area (workspace), the changes in labour productivity are shown using most recent study results and, as far as reasonably possible, compared to the information contained in the literature used in construction practice and for the purpose of preparing expert opinions. Jaafari (1988) specifies a minimum work area of 25 m² per worker for floor shuttering works.

2. Labour Consumption Rates and Productivity

This paper uses the term ‘construction process disruption’ to refer to any events that cause changes to the planned utilization of production factors (relative to the project costing). Such a disruption may have adverse effects (with respect to construction time, costs, quality, quantity etc.) but also a positive influence. For example, the actual labour consumption rates achieved during the construction process may be lower than the assumptions made in the costing exercise, which, in turn, means that the achieved construction output exceeds the planned output (while the quantity and quality of production factors remain unchanged).The causes of construction process disruptions may be diverse; they may also superimpose or reinforce each other. Construction process disruptions need not necessarily result in additional cost. If such disruptions occur, their effects on productivity should be investigated in order to determine whether they affect overall productivity (see Figure 1) or merely certain components of productivity. Productivity is the key indicator for evaluating the effectiveness of specific works or of the entire production or economic process. Productivity is expressed as the ratio between output and input; it is characterized by complex interdependencies. The degree of overall productivity is determined by the efficiency in combining elementary production factors. Elementary productivity is composed of labour, equipment and material productivity. Elementary productivity is significantly influenced (planned, managed, controlled, organized etc.) by discretionary productivity. All of these components should be considered adopting a holistic, networked view, rather than applying an isolated optimization approach. The key indicator of labour productivity is the labour consumption rate for activities requiring a high amount of labour.

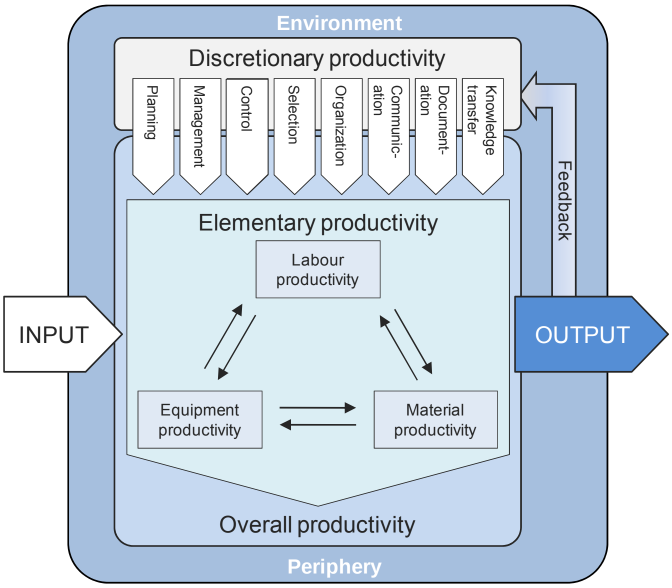

Figure 1: Components of overall productivity (illustrative example)

There is a direct correlation between labour consumption rates and productivity. Productivity is reduced if labour consumption rates increase (and vice versa). The labour consumption rates LCR [wh/unit] are obtained by dividing the total hours worked W [wh] by the production output Q [unit]; they are calculated using Eq. 1.

$$LCR = \frac{WH}{Q} \tag{1}$$

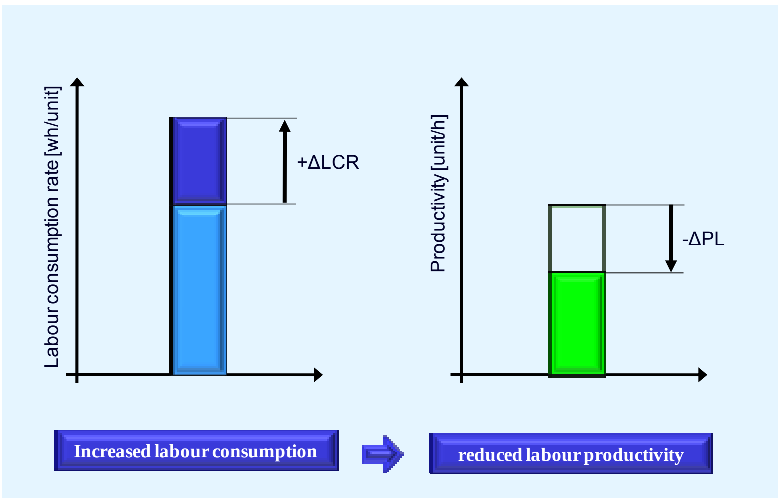

Figure 2: Correlation between labour consumption rates and productivity

If, for example, a labour consumption rate of 5 wh/m³ was assumed for reinforced concrete works, and if the actual labour consumption rate recorded during the construction process amounted to 7.5 wh/m³, the labour consumption rate would have increased by 50% compared to the original calculation (see Figure 2). The reciprocal of the labour consumption rate is used to calculate the labour productivity P [unit/h] relative to the labour consumption rate (see Eq. 2) (Hofstadler, 2007).

$$P = \frac{1}{LCR} \tag{2}$$

In the reinforced concrete works example mentioned above, the labour consumption rate increase by 50% translates into a 33% reduction in labour productivity (from the initial value of 0.2 m^3/wh to approx. 0.13 m^3/wh). Causes and causative factors of productivity losses are not dealt with in this paper.

3. Methods and Statistical Bases

The methods used for collecting, analysing and interpreting data are crucial to arrive at valid and reliable results. This paper refers to data collection methods in general and the method applied to this study in particular. In addition, the design of the questionnaire and analysis of data are outlined.

3.1 Methods of data collection

Various methods are used to obtain empirical data, depending on the specific field, academic discipline or subject matter of the study. Experiments are mainly used in the natural sciences whereas the social sciences utilize a wide array of data collection methods, including field research, systematic observation, surveys, and content and text analyses. Surveys include written, face-to-face or telephone interviews. Interviews and standardized questionnaires are most frequently used for data collection. These methods belong in the category of primary data collection (as opposed to a secondary analysis of existing data).

3.2 Expert interviews

Expert interviews serve an exploratory purpose and provide orientation in the field. Also, they can be used as the only instrument to collect data. The expert survey method appeared most appropriate for this study due to the subject of the evaluation and questions to be answered. An expert survey can deliver reliable data in a previously under-researched area. Experts are individuals possessing specific knowledge in a clearly defined field; they are used as a source of specific knowledge during the interview.

3.3 Construction experts as the target group of the sample

The relevant attributes for sampling were determined in advance. The most important characteristics included several years of experience in the construction industry, theoretical and practical knowledge in the respective field of specialization and sufficient professional experience of the experts. Employees of building contractors (from both construction trades and industry) were defined as the target group for the expert interviews with respect to shuttering works. For the expert interviews pertaining to shuttering works, employees were identified who were experienced in process planning, costing of quotations and individual works, execution of construction and final costing. This approach ensured that the collected information met a high quality standard.

3.4 Questionnaire design and subsequent survey

Basic rules of questionnaire design were adhered to in the course of preparing the relevant standardized questionnaires. Questions were formulated in clear and concise everyday language and supported by images if and when required. The preparation and wording of the questionnaires relied on the principles of simplicity, neutrality, clarity and single-dimensional nature of questions. In the interviews, factors that may cause productivity losses in a construction site environment were investigated and checked for possible correlations. For shuttering works, the total number of interviewees was 19. Despite the fact that a standardized questionnaire was used during the survey, interviewed experts were given the opportunity to clarify issues with the interviewer. This approach enabled them to develop a better understanding of the survey, which was to result in more reliable data.

3.5 Analyses and analytical methods

The outcomes of the expert survey were initially subjected to comprehensive exploratory analyses.

3.5.1 Exploratory analysis

An exploratory data analysis should generally be carried out prior to any other analyses of existing data in order to develop a basic understanding of the collected data. This work step is performed to check data plausibility and distributions, and to identify outliers. A range of so-called ‘location and spread parameters’ is available to assess a certain distribution of values or to compare it to other distributions. These parameters were used to determine mean values, standard deviations, standard errors of mean, coefficients of variation, median, minimum and maximum values, spreads, and the skewness of distributions. In addition, data were checked for normal distribution, and a box plot was used to establish a graphical representation of answer distributions.

This paper provides box plots of the variables to graphically illustrate their distributions. A box plot (cf. Figure 3) describes the location and spread of a distribution and indicates possible outliers (Emerson/Strenio, 2000).

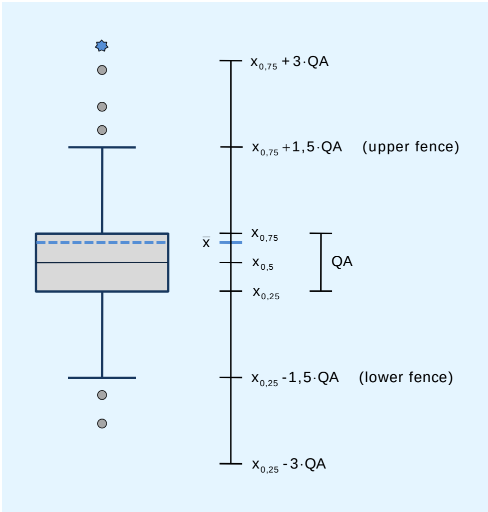

Figure 3: Box plot

Box plots are interpreted as follows: the box reflects 50% of all values (distance between the first ($x_{0.25}$) and third ($x_{0.75}$) quartile); the solid line inside the box marks the median. 25% of all cases are always located between the median and the top/bottom of the box. Values located above the 'upper fence' or below the 'lower fence' are considered outliers in the literature (marked by a circle). Any values located more than three inter-quartile distances away from the box margin are termed extremes (marked by an asterisk). However, these are only formal guidelines; additional underlying criteria need to be considered in order to determine whether a value is actually an outlier. The dashed line in the upper part of the box marks the arithmetic mean. The box plot shown above thus proves that the mean deviates from the median value, and is apparently shifted toward the top end by some outliers.

3.5.2 Detection of outliers

It is important to detect outliers because extreme values may strongly distort the overall distribution pattern, which may, for instance, compromise the reliability of the arithmetic mean. This distortion is often (and primarily) seen in small sample sizes. The influence of individual extreme values on statistical parameters, such as mean values, decreases in line with the increase in the sample size.

Robust parameters

Aside from the arithmetic mean, there are several so-called 'robust location parameters' (Wilcox, 2001). These include the median (which, however, does not use all information provided by the data) and the so-called 'M-estimators' (similar to maximum likelihood) known in robust statistics. Huber considered such estimators a robust 'intermediate' between median and mean (Huber, 1964). These M-estimators provide a varying degree of weighting of the values during the iterative computation of the mean value (the greater the distance, the smaller the weight). Huber's M-estimator is the only estimator that still assigns a certain minor weight to distant outliers. All values are fully weighted (with 1) within a standardized distance from Huber's mean estimator defined in a preceding step applying the tuning constant c. Outside this area, the weight decreases in line with the increase in the distance. Compared to this approach, the arithmetic mean would thus be an M-estimator applying a weight of 1 to each of the values regardless of how extreme the outlier is. This type of M-estimator thus 'attracts' outliers/extremes to the 'main mass of data'. Table 1 provides an overview of the c values commonly applied to Huber's M-estimator. The fully weighted (= 1) standard normal distribution range should be considered a nominal parameter.

Table 1: Huber's M-estimator

M-estimator (Huber Proposal 2)	H19	H16	H12	H8
Tuning constant c	1.960	1.645	1.282	0.842
Fully weighted area for mean computation	~95%	~90%	~80%	~60%

The value assumed for c depends on the number and distance of outliers, the type of distribution and the underlying considerations applied to the study.

4. Influence of Minimum Work Area on Productivity

On the construction site, the contractually agreed works are performed on the basis of discretionary specifications by combining elementary production factors. The client usually specifies clear contractual outcomes to be achieved; the contractors try to optimize their elementary factors in such a way that the works owed under the contract can be carried out at the lowest possible construction cost. When combining the production factors, the workspace/work area has a strong influence on the achievable level of productivity. Productivity losses occur whenever the relevant limits are underrun.

4.1 Significance of minimum workspace/area

Productivity losses ΔPL occur if the work areas provided underrun the minimum areas specific to the works considered. The parties involved in the project usually agree on this matter. There is still uncertainty and disagreement regarding accurate figures pertaining to relevant minimum work areas and the magnitude of related effects. Figure 4 shows the qualitative correlation between the number of workers, minimum work area (limit area) and productivity. As long as the average minimum/limit area per worker is not underrun, it can be assumed that an average 'standard productivity' level is reached. The average work area per worker is getting smaller as the number of workers increases. Productivity losses occur if less than the specific minimum area is provided. Compared to the client, the contractor usually assumes a higher level of productivity loss 'sustained' on the construction site.

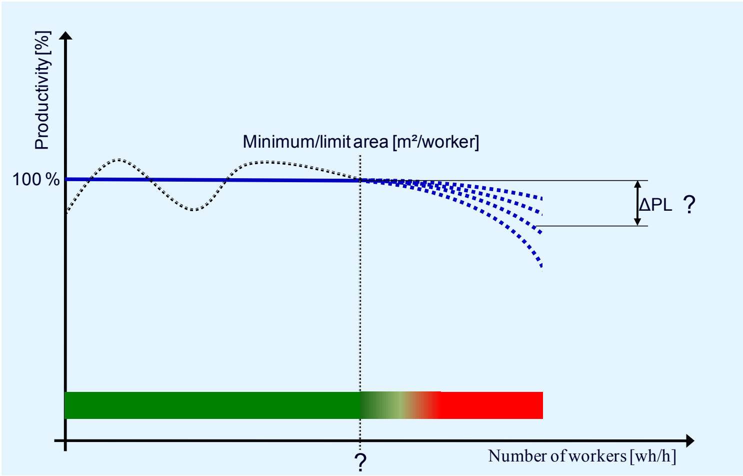

Figure 4: *Correlation between number of workers, minimum work area and productivity (excluding consideration of optimal team size)*

In addition, the parties arrive at a different assessment of the further loss trend that results from a further increase in the number of workers. To achieve their standard performance level, workers require a minimum work area/workspace in order not to be disturbed by the activities of other team members or workers belonging to other teams or construction trades. The qualitative correlation between work area and productivity is well-known whereas no indications, or even diverging opinions, exist with regard to the dimensions of the minimum work area [m²/worker] depending on the specific activity and structural component to be worked on (such as a wall).

5. Losses of Productivity in Shuttering Works – Minimum Work Area for Flat Floors

The following sections of this paper derive the minimum work area per worker [m²/worker] required for flat floor shuttering works in order to perform the work at the ‘standard’ productivity level. Following the underrun of the minimum work area, labour consumption rates show an increase whose trend is illustrated as a function of the extent of work area reduction. These labour consumption rate increases can be used to calculate losses of productivity.

5.1 Minimum work area for flat floor shuttering works

All of the 19 experts specified a required minimum/limit work area. The obtained minimum work area values ranged from 20 m^2 to 50 m^2. The arithmetic mean derived from the nineteen specified values amounted to 29.42 m^2 (the median equalled 30 m^2); the standard deviation amounted to 8.75 m^2. The specified values concentrated on the lower portion of the above-mentioned range (the skewness of the distribution equalled 0.71; data did not show a normal distribution according to the Shapiro-Wilk test; $p<0.05$). The box plot analysis revealed no outliers; at the same time, the histogram illustrating the distribution of the specified values was analysed, which showed one possible outlier (a minimum work area of 50 m^2). The further analysis aimed to determine a plausible value for the minimum work area. Huber’s M-estimator was calculated for this purpose. A tuning constant c of 1.645 was used

(H16), which means that about 90% of all values were fully weighted in the computation of the mean estimator. By contrast, the outlier of 50 m² was assigned a lower weighting. This approach resulted in an M-estimator amounting to 29.05 m². The difference between the arithmetic mean and the M-estimator equalled only 0.37 m², which can be considered negligible in construction practice. On the basis of this analysis, the minimum work area is assumed to be 29 m² for practical purposes (derived from Hofstadler, 2008).

5.2 Productivity losses following a minimum work area underrun

All of the 19 interviewed experts specified values pertaining to productivity losses for flat floors.

5.2.1 Description of collected data

The exploratory data analysis showed that both the spread of answers and the standard deviation increased in line with the continuous work area reduction (from 0 to 60%). When considering the coefficients of variation, we find the greatest spread of expert opinions for a work area reduction of 10%; this spread then ranges from approx. 43 to 56% for 20 to 60% work area reductions, which is relatively significant and suggests that opinions diverge among experts. In addition, the standard error of mean increases, which suggests a rather inaccurate estimate of the true mean value, especially for minimum work area underruns equal to or greater than 40%. Skewness is positive for all variables, which indicates right-skewed distributions where the major share of answers tends to be located at the lower end of the scale for all variables. The majority of experts tends to specify rather low productivity loss estimates. The values do not show a normal distribution according to the Shapiro-Wilk test ($p<0.05$). The following box plots (see Figure 5) indicate the existence of some outliers or extremes.

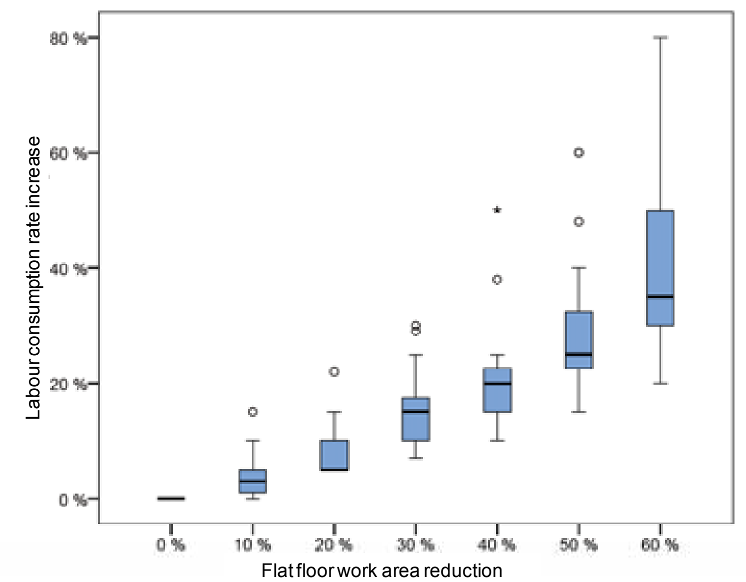

Figure 5: Box plots: Labour consumption rate increase in the case of a minimum work area underrun – flat floor shuttering works

With the exception of the 60% work area reduction, each of the variables includes at least one outlier. The 40% work area reduction reveals two extremes (marked by only one asterisk because the values are identical); the 50% work area reduction shows three outliers (two of these values are identical). When simultaneously analysing the histograms (not shown in this paper), however, three possible outliers (80% labour consumption rate increases) were identified for the 60% work area reduction. In the case at hand, the use of Huber's M-estimator is again justifiable both in terms of the underlying criteria and from a statistical point of view. All expert opinions are still taken into account although isolated outliers distort the curve (cf. Figure 6) to a lesser extent than recorded for the arithmetic mean. The disadvantage of the mean value trend curves lies in the fact that it also includes the full weighting of outliers. As a result, no outliers were excluded from the analysis.

5.2.2 Graphical representation of productivity losses

Figure 6 shows the labour consumption rate increase trend curves on the basis of arithmetic means (curve entitled 'Flat floors - arithm. mean') and M-estimators (curve entitled 'Flat floors – M-estimator H12').

The disadvantage of the mean trend curve lies in the fact that it also includes the full weighting of outliers. A tuning constant c of 1.282 was used for calculating the trend curve of Huber's M-estimator (H12), which means that approx. 80% of all values are fully weighted in the computation of the mean estimator. Compared to the previous situation, the covered area was determined at 80% in order to enable a less significant weighting of the three outliers identified for some of the calculations for the purpose of determining the M-estimators.

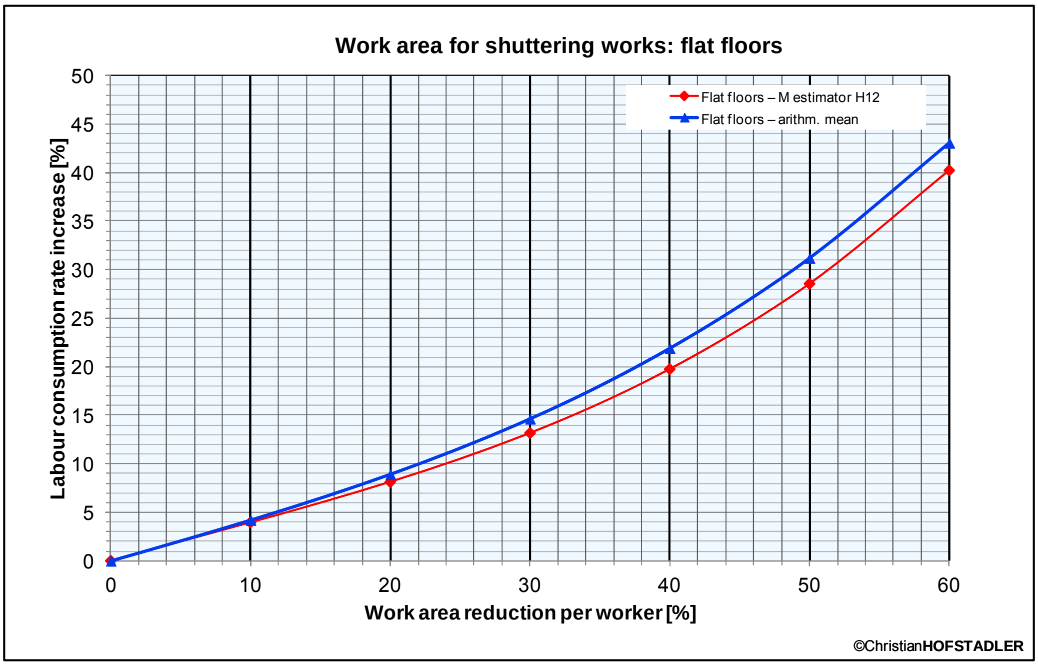

Figure 6: Labour consumption rate increase as a function of the calculation method (derived from Hofstadler, 2008)

The M-estimator trend curve is considered most appropriate for practical purposes. The M-estimator trend curve shows smaller labour consumption rate increases for greater work area reductions. The characterization of the trend reveals no significant difference between the curves. The greatest relative difference is shown for the 30% work area reduction (approx. 10%); the greatest absolute difference amounts to about 2.8 percentage points for a 60% reduction in the minimum work area WA_{MIN} [m²]. The actual work area WA_{EX} [m²] reduction is calculated using Eq. 3 (applies to $WA_{EX} \leq WA_{MIN}$).

$$WA_{RED} = \left(1 - \frac{WA_{EX}}{WA_{MIN}}\right) * 100 \tag{3}$$

For the works under study, the existing work area WA_{EX} [m²] and the minimum work area WA_{MIN} [m²] need to be considered. The calculated work area reduction WA_{RED} [%] can then be used in the equation for calculating the percentage of the labour consumption rate increase.

The increase in the labour consumption rate determined by the mean trend curve is obtained by applying the degree of work area reduction using Eq. 4.

$$\Delta LCR_{WA,INC} = 0.000086 * WA_{RED}^{3} - 0.000079 * \quad {}_{RED}^{2} + 0.412690 * \quad {}_{RED} \tag{4}$$

The increase in the labour consumption rate determined by the M-estimator trend curve can be calculated using Eq. 5. Again, the work area reduction is used in the equation.

$$\Delta LCR_{WA,INC} = 0.000111 * WA_{RED}^{3} - 0.002274 * WA_{RED}^{2} + 0.406838 * WA_{RED} \tag{5}$$

The following applies to the calculation of the labour consumption rate increase $\Delta LCR_{WA,INC}$: $0\% < WA_{RED} \leq 60\%$

The reduction in productivity $\Delta PL_{WA,RED}$ [%] due to the minimum work area underrun is calculated using Eq. 6, applying the percentage of the change WA_{RED}.

$$\Delta PL_{WA,RED} = 0.000036 * WA_{RED}^{3} - 0.000277 * WA_{RED}^{2} + 0.364955 * WA_{RED} + 0.043316 \tag{6}$$

The following applies to the calculation of the loss of productivity $\Delta PL_{WA,RED}$: $0\% < WA_{RED} \leq 60\%$

6. Summary

This paper outlined correlations between labour consumption rates and productivity from a construction management point of view, with particular emphasis on the effects on labour productivity. The 'minimum work area' concept and its relevance and influence on productivity were described. For flat floor shuttering works, data pertaining to the specific limits/minimum work areas were collected in expert surveys, and statistically analysed. The resulting value is considered a representative minimum that can be used in construction practice. In addition, the trend curve of the labour consumption rate increase was determined as a function of the increasing minimum work area underrun on the basis of the expert interviews. The findings of the expert surveys were subjected to exploratory data analyses with the aim to detect outliers that may distort the overall distribution pattern. Following the calculation of the M-estimators according to Huber, polynomial trend curves were shown to demonstrate the influence of the minimum work area underrun for flat floor shuttering works. A simple conversion step is sufficient to derive productivity losses from the labour consumption rate increases. The results of the study can be used for assessing and calculating productivity losses in the areas described above. Further productivity studies have been and are currently being conducted. Their results will be published at a later stage following comprehensive data analyses. Investigations are also planned or underway for other areas of construction, such as dry wall and masonry construction or electrical installations.

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Performance management framework for construction industry

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Abstract

In recent years many performance management models have seen the light of day, among which the Balanced Scorecard (BSC) and EFQM Excellence model (EFQM) are the most popular and widely used. Despite their popularity, there is a scarcity of literature which supports the applicability of these models on construction industry. Therefore, the purpose of this paper is to design a performance management framework for the construction industry, by analyzing the empirical relationship between European excellence model (EFQM) and the Balanced Scorecard (BSC). To form the framework, data were collected by way of the EFQM self-assessment method on 34 construction companies in Croatia and Bosnia and Herzegovina. Afterwards the framework was verified in a construction company in Croatia. The research results suggest that EFQM and BSC are complementary tools for managing performance. This confronts many previous studies that have put BSC and EFQM on the opposite sides. Furthermore, we have found that EFQM is the missing link of strategic control when using BSC. Otherwise BSC, when used alone, can easily become generator of lagging measures. Therefore construction companies need to engage in benchmarking efforts (i.e. EFQM self-assessment) together with BSC in order to: benchmark its performance against their rivals and to incorporate the weaknesses found in to the strategy. This paper contributes to project management (PM) research by exploring the relationship between EFQM and BSC in a project oriented industry (i.e. the construction) that has not yet fully accepted capacities of PM. Furthermore, this is the first study that offers insights into the relationship between BSC and EFQM based on data gathered from real self-evaluations in construction industry.

Keywords: performance management, the balanced scorecard, EFQM excellence model, benchmarking, construction industry

1. Introduction

Practice has shown that their regular use of performance management frameworks (PMM), (e.g.: the Balanced Scorecard (BSC), EFQM Excellence model (EFQM), Malcolm Baldridge National Quality Award (MBNQA) etc.) can positively influences business results (Ahn 2001; Bauer et al. 2004; de Waal 2003; Hoque and James 2000; Malina and Selto 2004; Sandt et al. 2001). As soon as Kaplan and Norton (1992) introduced BSC, it became a hit and showed its advantages over the other PMM models. This was especially evident in the high strategic focus and the communication of strategic objectives throughout the organization. Yet besides the traditionally criticized financial indicators (Beatham et al. 2004; 2005; Chan 2004; Halachmi 2005), BSC has also introduced additional perspectives. Still, the tool has been criticized (Kagioglou et al. 2001; Sinclair and Zairi 1995a; b; c) for not being able to align strategy with the environment or conduct benchmarking (French 2009a; French 2009b; Vukomanović et al. 2008). EFQM has become well accepted in practice as well, especially for encouraging continuous improvement through self-assessment and benchmarking (Cobbold and Lawrie 2002; de Waal and Counet 2006; Niven 2006). However the model has also been criticized for its weak linkage with strategy and strategic integration processes (Junnonen 1998).

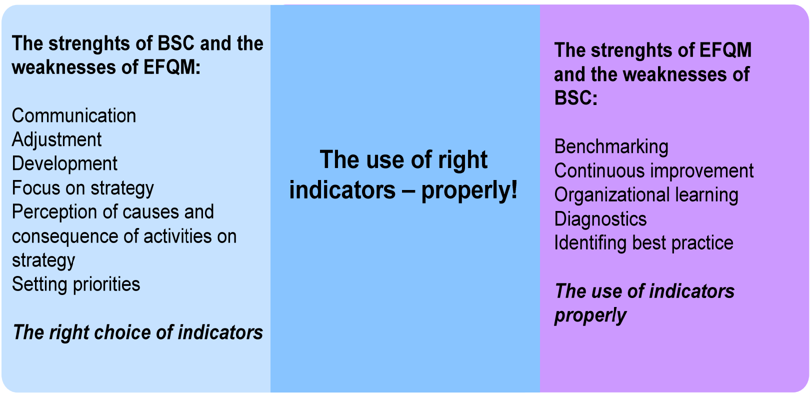

Figure 1. Strengths of EFQM and BSC models

Unfortunately, today more than half of BSC and EFQM implementations fail (Bourne et al. 2003; Hakes 1995; Neely 2000; Neely 2002). Furthermore, only 5% of employees understand the company's strategy, only 25% of managers have initiatives closely tied to the strategic priorities, only 40% of organizations link their budget with the strategy, and less than 15% of project teams spend even less than 1 hour discussing about the strategy (Johnson and Kaplan 1987; Kaplan and Lamotte 2001; Kaplan and Norton 2004; 2006). Many researchers and practitioners have suggested integration of BSC and EFQM into one unified system, but this has not yet been achieved (Andersen et al. 2000; Bassioni et al. 2004; Beatham et al. 2004; 2005; Braam and Nijssen 2004). Therefore the aim of this research is to design a conceptual framework for PMM, comprised of both philosophies: the strategic focus of BSC and the benchmarking ability of EFQM. The framework uses an Analytic Hierarchy Process (AHP) to bridge the gap between BSC and EFQM. AHP is used twice; once as a multi-criteria decision model for prioritizing strategic objectives (where EFQM criteria of excellence become the prioritizing criteria) and once as a multi-criteria model for selecting strategy aligned Key Performance Indicators (KPI) (within four BSC perspectives). The framework uses BSC for controlling the strategy implementation and EFQM as the link with competitive environment. Besides the integration, this research also challenges EFQM's applicability in construction industry in South East Europe (SEE) (Croatia and Bosnia and Herzegovina), where many Western authors questioned its applicability on transitional economies.

2. Theoretical background

2.1 Brief overview of PMM

Over the years, the construction industry has mainly used three groups of performance management models: KPI based models, BSC based models and EFQM based models (Robinson et al. 2004). Robinson (2004) observed 100 companies and 70 top consultants in the U.K. and has found that: more than 50% use EFQM or BSC, 26.4% use different KPI models and only 22.8% companies do not use any of these models. BSC popularity can also be seen in the fact that c. 60% of The Fortune's TOP 1000 companies today use BSC (Niven 2006). The literature review showed a large amount of studies written on the topic of performance management e.g.: Hoque and James (2000), found the importance of nonfinancial performance in bank studies; Ahn (2001) stressed the importance of BSC for a strategic business unit; Sandt, (2001) explored manager satisfaction through Balanced Performance Measurement Systems and has found it highly applicable; de Waal (2006) gave lessons learned from BSC in public and private companies and discovered the model's deficiencies, especially in public sector; Bauer et al. (2004) comprehensively researched benchmarking of performance and listed applicable benchmarking models; Malina and Selto (2004) explored the selection process of performance measures and found a vast scarcity of literature etc. Furthermore, during the last decade alone one paper was published every 5 hours in the working day (Abudayyeh 2004; Neely 2002). Consequently, at the end of 2004 there were more than 12 million web sources on the subject of PMM (Bauer et al. 2004). This strong and positive trend shows the importance of the subject and the current interest of academia in PMM.

2.2 BSC vs. EFQM

Kaplan and Norton (1992) presented The Balanced Scorecard (BSC) in 1992. BSC balances between financial and non-financial indicators and measures critical activities and processes in order to control implementation of a business strategy (Kagioglou et al. 2001). A balance can be found in short-term and long-term objectives, as well as in quantitative and qualitative measures. Kaplan and Norton (Kaplan and Norton 2006) state that BSC supplements traditionally criticized financial indicators with indicators from three other perspectives: Investor/Shareholders, Clients, Internal processes and Learning and innovation. BSC possesses great strengths e.g.: safety from sub-optimization (it forces senior management to consider the majority of operational problems), it communicates strategy objectives throughout the organization and, if implemented correctly, generates only a small number of activities to control. It also identifies the company's present state and future business potential and can be applied (so the authors claim) to both for-profit and not-for-profit organizations (Halachmi 2005; Kaplan and Norton 2004). Over the years, BSC has received a large number of compliments from both industry and academia (The Harvard Business Review at the end of the millennium declared BSC to be "the most influential management idea in the past 75 years" (Niven 2006)). Nevertheless, the model has been criticized for over simplicity (Kagioglou et al. 2001) and for not covering all aspects of performance (Radujkovic et al. 2010). EFQM Excellence model was originally developed as a quality management system in 1991 (Hillman 1994) by the European Foundation for Quality Management (now called just EFQM). Even though the word "business" was replaced with “excellence”, the model is based on TQM principles and has recently been advocated by many authors e.g. (Andersen et al. 2000; de Waal 2008; EFQM 2005; El-Mashaleh et al. 2007; Vukomanović et al. 2008). EFQM (the foundation) sees the purpose of their model in assessing a company’s excellence, identifying deviations of performance against the best practice and generating a stimulus in the form of improving activities (Beatham et al. 2004). The model is based on “8 principles of excellence”: result orientation, development of personnel, client focus, continuous learning and innovation, leadership and continuity in purpose, partnership development, facts and process oriented management, and public responsibility. EFQM assesses performance through the nine weighted criteria and their respective sub-criteria. Over the years, EFQM has become a very popular tool in the construction industry in Europe (more than 60% of companies have implemented it (Andersen et al. 2000; Robinson et al. 2004)). Nevertheless, the model has also received a great deal of criticism (Andersen et al. 2000; Codling 1995; Lam et al. 2004; McCabe 2001; Sharif 2002), especially for not being able to focus and connect with strategy. It is interesting that BSC’s strengths, at the same time, are the weaknesses of EFQM, and vice versa, which shows these models to be complementary tools and not exclusive ones (see Figure 1). This challenges many past studies that have suggested just the opposite (Cobbold and Lawrie 2002; Dror 2008; Lawrie et al. 2004; Rusjan 2005; Shulver and Lawrie 2007). Therefore, in this study, we questioned whether EFQM and BSC, based on their complementary attributes, can be integrated into a PMM framework which will enable companies to conduct strategic control. BSC and EFQM are based on different concepts and approaches in managing performance. BSC has evolved from original performance measurement into a modern management system. It favors a clear focus on strategy and should serve as the platform for other performance initiatives. The model is based on a dynamic, individual and close relationship between causes and consequences. Since neither the criteria of performance assessment nor the selection of KPIs are predetermined, the model is descriptive and cannot be used for external benchmarking (competitive, industrial or generic). It measures the proper processes, but it cannot control whether these processes are being measured properly, e.g. KPIs can be selected in respect to strategic objectives, and then, as the measurement process progresses, frequently adjusted. Thus BSC will only subsequently signalize if something went wrong when the expected Finance Performance is not met and only after substantial damage has occurred (Mao et al. 2007). This only shows how the process of strategic implementation can become isolated from the environment and how BSC can become the generator of lagging measures. EFQM is prescriptive and based on a static design (just the opposite of BSC). It consists of a set of standards and strategic objectives which (as EFQM states) can be applied in any type of organizations (EFQM 2005). The causal relationship between consequences and causes is only implicitly elaborated. Companies will find EFQM much easier to use than BSC, since the methodology of self-assessment is prescribed. EFQM maintains the relationship with the environment and can signalize which business processes are (or not) aligned with changes in the competitive environment and thus it provides an early warning system for strategy reformulation. On one hand, the greatest strength of EFQM over BSC is its ability to conduct benchmarking and thus obtain leading measures of strategy control. On the other, the greatest weakness is the loss of strategic focus. Some authors have suggested the integration of these two models (Andersen et al. 2000; Cobbold and Lawrie 2002; Niven 2002), but this has not yet been achieved.

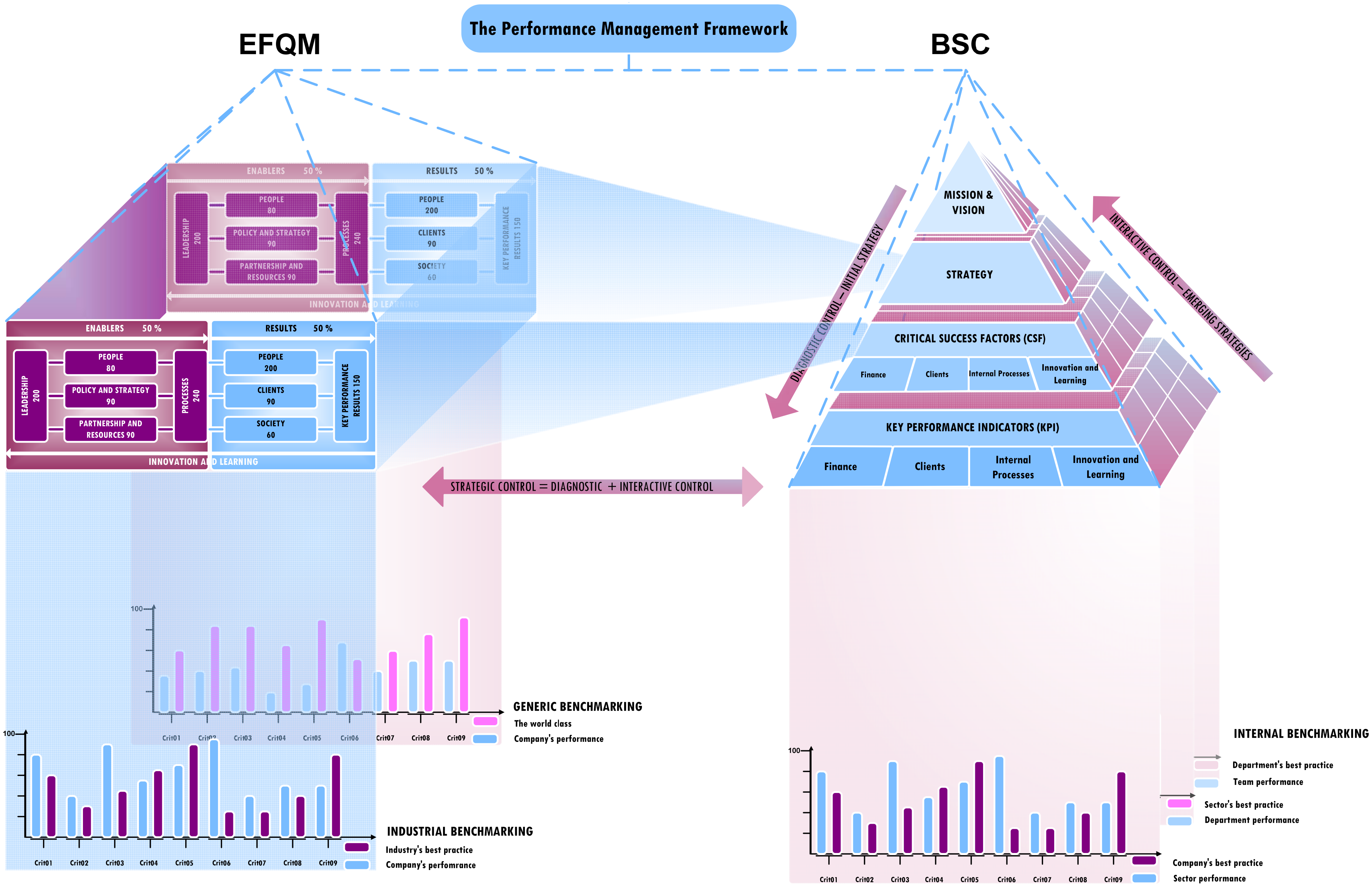

Figure 2. The two sides of the Performance Management Framework

3. Designing the framework

We started developing the framework (see Figure 2) in 2007. After initial literature review, which delineated EFQM and BSC weaknesses and strengths, we concluded that for a holistic approach to managing performance, these two models should be tied together. In order to validate EFQM use in construction we assessed 34 middle and large companies (out of 142 that operate in Croatia and Bosnia and Herzegovina) using official EFQM templates and suggested methods, yielding with best practice of the construction industry. Correlation among the EFQM criteria results was calculated in order to check if original weights were set right. BSC was then implemented (during the period of one and a half year) into one large construction company in Croatia. After BSC had been found applicable for the construction, the model was afterwards integrated with EFQM. The framework balances between inner (BSC) and outer performance (EFQM). On one hand BSC is used for: identifying strategic priorities; communicating the strategy throughout the organization; enabling diagnostic control by pressuring strategic objectives on to the lower levels; enabling interactive control by discovering new initiatives at lower levels and checking whether the strategy has achieved strategic objectives. On the other hand, EFQM is used to check if the strategic priorities are aligned with the environment by: conducting benchmarking; identifying best practice and finding areas for improvement. Altogether, both sides of the model are important to achieve strategic control of performance.

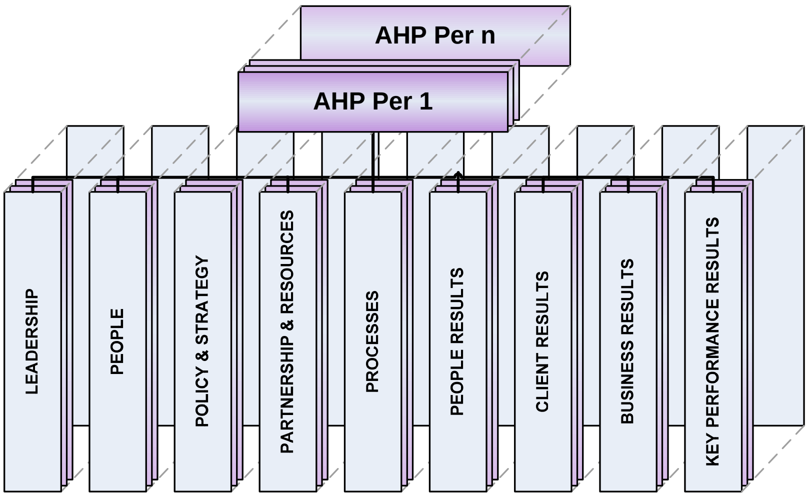

Figure 3. AHP model used for ranking the strategic objectives

During the research we found Analytic Hierarchy Process (AHP) to be the most suitable method for connecting EFQM and BSC. AHP (Saaty 1980) is a decision-making tool, based on the Eigen value approach to pair-wise comparisons of multiple criteria (Vaidya and Kumar 2006).The method has been used in a wide variety of areas, including: resource allocation, public policy (Shahin and Mahbod 2007); strategic planning of organizational resources (Saaty 1990); the evaluation of strategic alternatives (Tavana and Banerjee 1995) etc. Yet, only a small number of studies have developed a standard method for prioritizing KPIs (Shahin and Mahbod 2007). The framework employs AHP twice: once when setting priorities among strategic objectives for each perspective of BSC (Per 1 to Per n; where n represents number of the perspectives, figure 3); and once when setting priorities for KPIs within each strategic objective within BSC. Their pair-wise ponders are calculated as discrepancies of performance between best practice and the performance of the observed company (the left side of the figure 2). The performances are identified through the EFQM self-assessment process.

In this way the first AHP model provides a listing of CSFs that are ranked in terms of the competitive surroundings. The ranks are afterwards assigned to a strategy map in BSC, in order to identify priorities among the different strategic areas (we named these areas; strategy chains).
After initial CSF rankings, KPIs are selected in the second AHP model, where they are ranked against SMARTER criteria (Specific, Measurable Achievable, Relevant, Time-bound, Extended/Exciting and Rewarding/Recorded). This is done for every perspective of BSC. Shahin and Mahbod (2007) have already developed similar model but with SMART criteria. We added "E" and "R" since we wanted to emphasized the need of integrating incentives with performance. The same did Beatham et al. (2005) when developing their framework. Thus, the model generates a listing of ranked KPIs which are afterwards assigned in to the four perspectives of BSC. Finally, figure 2 shows how the framework balances between outer (benchmarking using EFQM excellence model) and inner performance (the performance of implementing business strategy) and explains the idea of integrating these two models in to one framework.

4. Verifying the framework

Construction companies in Croatia have had little experience with PM processes other than maintaining operations. This was due to more than 50 years of central planning in large state-owned enterprises (the former Yugoslav construction industry - where the two countries of this study originated from - was marked by companies with more than 15,000 employees) who were charged with prescribed production targets (Filatotchev et al. 2000). Croatian construction industry has a specific business culture. Unlike common law practices (e.g. the U.S., U.K., Australia…), Croatia has a strict law regulation (originated from French law system; "Code de civil") that firmly defines project stakeholders (investors, contractor, supervision and designers). The law still does not recognize project managers as interested parties in construction projects. Furthermore, owing to the former socialist regime policy, modern project management practices are still unknown to the construction companies. To verify the framework we implemented it in a construction company in Croatia (under alias IZV-7). IZV-7 was selected among the 34 companies which were assessed using EFQM model. The company operates in Croatia and Bosnia and Herzegovina and has built a good reputation in building large residential house blocks. At the end of 2010, IZV-7 had revenue of 380 Mio EUR. The verification was conducted through the five steps presented below. Due to a confidentiality agreement with IZV-7, we will only elaborate steps which reflect the research results, i.e. joining BSC and EFQM by incorporating benchmarking results of EFQM surveys in to the strategy map of The Balanced Scorecard. In this way will show how these two models were integrated in to one single framework and show two different decision making models.

STEP 1: Initial strategy

First, lagging measures were identified at the highest level (finance) and linked on to the lowest levels (Innovation and learning). Hence the causal picture of the strategy was formed (in form of a strategy map). Second, for each lagging CSF, leading measures were identified. After this, the CSFs were distributed into the four perspectives of BSC and grouped into "Strategy Chains". As IZV-7 has not granted us permission to show the strategy map we cannot elaborate the strategic objectives in further detail.

STEP 2: Performance self-assessment using EFQM

During this step we conducted EFQM self-assessment of 34 construction companies in SEE and benchmarked the best practice against performance of IZV-7. The EFQM self-assessment was carried out during one and half year period where we collected the data through formal EFQM procedures and templates. Ratios between performances of best practice and IZV-7, which were calculated from the scores in table 1, are shown on table 2. If we take a closer look at e.g. leadership criterion, we will see that IZV-7 has four times weaker performance than the best practice has (64 against 16). Furthermore, these results also identify the weakest areas in managing an organization (in this case these were: Policy and Strategy, and People results; with scores of 13,00 and 22,50 respectively). The best practice in Croatia had a score of 652,7, while the performance of IZV-7 was at 251,5 out of maximal 1000 points. In other words, IZV-7 had only 25,5% of excellence achieved.

Table 1. Comparison of performances between the best practice and IZV-7

BEST PRACTICE	**points**	**IZV-7**	**points**
1. Leadership	64	1. Leadership	16
2. Policy and strategy	65	2. Policy and strategy	5
3. People	72	3. People	24
4. Partnership and Resources	84	4. Partnership and Resources	43
5. Processes	117	5. Processes	59
6. Client results	125	6. Client results	46
7. People results	45	7. People results	2
8. Society results	42	8. Society results	21
9. Key performance results	113	9. Key performance results	34
Overal score	652,7		251,5

Hence in this way IZV-7 has learnt that in the period to come the company should put more focus on planning and controlling of business strategy rather than on processes (the processes, represent technical capabilities and skills of construction companies, e.g.: to deliver on time, on cost, technological capabilities etc.). Furthermore, the strategy has to emphasize improvement of leadership skills (mission and vision have to be defined, company supports mentoring, higher accountability etc.) and people results (higher motivation, better communication, higher satisfaction of employees etc.) improvements. Table 3 shows top ten strategic objectives which cover the two aforementioned areas.

Table 2. Ratios between best practice and performance of IZV-7

ENABLERS		**RESULTS**	
1. Leadership	4,00	6. Client results	2,72
2. Policy and strategy	13,00	7. People results	22,50
3. People	3,00	8. Society results	2,00
4. Partnership and Resources	1,95	9. Key performance results	3,32
5. Processes	1,98		

STEP 3: Selection of CSFs using AHP

Table 3: Pair-wise weights for the AHP model for selecting strategic objectives

	Strategic objectives	**Priority (from AHP)**
1.	Separate ownership from management	0.910
2.	Define assignments for manager	0.861
3.	Introduce personal development plans	0.769

4.	Decrease costs	0.779
5.	Recruit highly educated employees	0.746
6.	Introduce rewarding policy	0.709
7.	Introduce project oriented policy	0.634
8.	Define business policy	0.619
9.	Develop a project management standard	0.614
10.	Improve control of subcontractors	0.551

In this step framework uses the discrepancies, identified by the benchmarking between the best practice and IZV-7, which were used to set priorities among CSF selection criteria (table 3). All of the CSFs were processed through the AHP model shown on figure 3 (EFQM criteria were introduced as the ranking criteria). Consequently, the AHP model produces a listing of CSFs, ranked according with their respective AHP weights. Thus, the steps 1, 2 and 3 allow the company to implement industrial benchmarking and align its strategy with the environment. This is important to acknowledge, because up to now, one of the biggest critique of BSC was the absence of a link that re-evaluates the strategy in respect with the competitive environment.

After we assigned the ranks to each critical success factor (CSF) in the initial strategy map, we could identify different areas, which we named "Weighted Strategy Chains" (WSC). All together there were four different WSCs, consisting of more than 40 strategic objectives. Using the scores assigned with every strategic objective, we calculated competitive importance for every WSC. In that way we selected the most relevant and discarded the other three less important WSCs. At the end, the strategy consisted of 16 strategic objectives (lagging and leading, across the four perspectives of BSC). We cannot elaborate this step in further detail because of the confidentiality agreement.

STEP 4: Selection of KPIs using AHP

In step 4, the framework employed AHP for the second time to form a decision making model for the KPI selection (elaborated in the methodology part). KPIs were ranked against the seven SMARTER criteria and the weights of pair-wise comparison were set by the management. After the KPIs were ranked, they were assigned within their respective BSC perspective. The steps 1-4 thus allowed IZV-7 to derive a BSC based on a list of KPIs which are linked with strategic objectives and which were aligned with the benchmarking results.

STEP 5: KPI cascade

This last step was used to communicate KPIs from the highest to the lowest management levels. In this cascade of indicators, three lower levels of the observed company had their own scorecard developed, where KPIs were closely tied with higher objectives. This step allowed the company to communicate strategy throughout the organization and implement internal benchmarking of performance between different hierarchy levels or different sectors. Even though this step was not primary objective of this research, it helped the company in communicating this new performance management initiative.

5. Conslucion

This framework has showed how BSC, if integrated with EFQM, can go beyond its original capabilities and how it can enable strategic control and conduct benchmarking in the fast changing environment. This study has also showed that EFQM and BSC can work together in and that they are complementary tools. These findings challenge previous studies that put these tools on opposite sides (Andersen et al. 2000; Cobbold and Lawrie 2002; de Waal 2003; de Waal and Counet 2006; Dror 2008; Rusjan 2005; Shulver and Lawrie 2007). This is important to acknowledge, since BSC, if used alone, could easily become the generator of lagging measures. Furthermore EFQM has shown to be an effective external link for BSC. The framework takes BSC beyond diagnostic and interactive control of business strategy and makes it a modern strategic control system (which constantly re-evaluates the strategy with larger context, i.e. competitive environment). The PMM framework employs EFQM as a tool for external benchmarking and BSC for diagnostic and interactive control. Even though Kaplan and Norton (2008) concluded that for efficient performance control, companies must have the four perspectives in balance, the PMM framework goes even further and balances between both; business opportunities and threats (EFQM) and implementation of strategy (BSC) (figure 2). Still, during our research, we have found EFQM inapplicable for public construction companies. This was mainly because many public organizations in Croatia have neither developed a clear mission and vision nor the business strategy. Furthermore, we have also found EFQM to be suitable benchmarking model for the contractor’s perspective in the construction projects, while with clients’ and consultants’ perspective was not the case. Finally, we designed the framework as the answer to many criticisms of current modern PMM models which emphasize the need of having a link with business environment and decision making model for selecting right KPIs. This framework has justified its theoretical presumptions, raised in the methodology part, since it has been verified in practice. Similar analogy of integration was used by Veen-Dirks and Wijin (2002), but instead of joining BSC and EFQM they joined BSC with the Critical Success Factor model. In future research a comparison of different decision making frameworks (e.g. Prometheus, Electra or Smart) with AHP is needed to discover the most efficient multi-criteria decision tool for integrating BSC and EFQM. Furthermore, the model’s wider applicability in practice should be further researched since it was not validated other industries than the construction. We strongly encourage such research activities in order to form an efficient and effective PMM tool, and thus help companies in achieving excellence.

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The Australian built environment: current challenges and innovative responses

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Abstract

The exploratory research presented in this discussion paper was undertaken as input to a major research grant application for the Australian Research Council. The research looks at the contribution of the Australian built environment to meet social and environmental needs. The paper examines the following research questions:

What are the main challenges facing the Australian built environment?

What types of building innovations might address those challenges?

The research questions were addressed through desk-top research, involving an international review of (1) relevant academic literature in top-tier construction management and general management journals, and (2) high profile industry reports published internationally. Future research will involve assessing the diffusion of the identified building innovations and gauging their impact on social and environmental goals.

Keywords: Australia, client, construction, contractor, innovation

1. Background

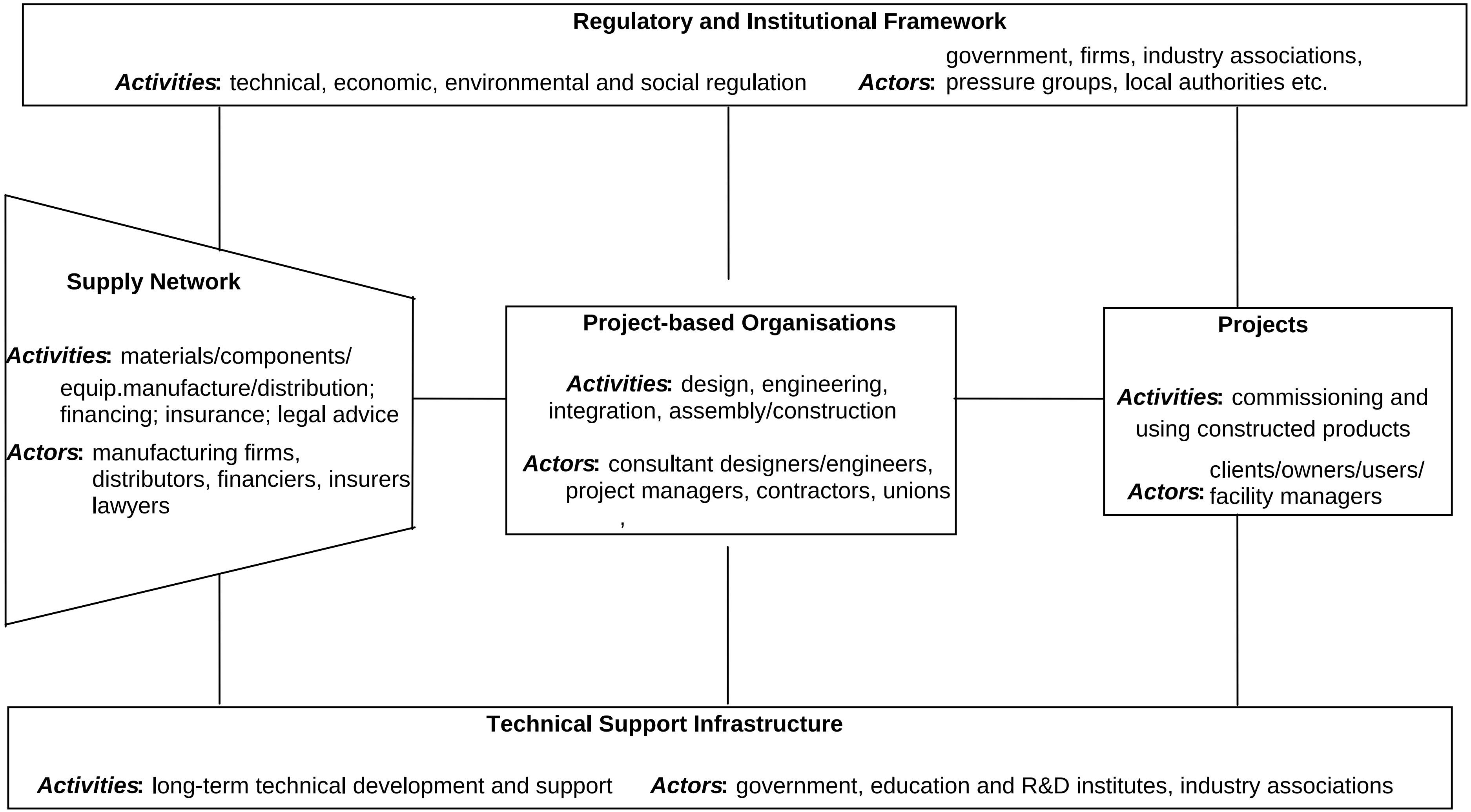
Australia's built environment is created and maintained by the construction industry. The statistical agencies of most developed countries define the industry quite narrowly to comprise only contractors. This definition gives a contribution to GDP of around 5-7%. However, using a 'product system' definition of the industry roughly doubles its GDP contribution to between 10-14% (Manseau, 2004, Ruddock and Wharton, 2004, DISR, 1999, Marceau et al., 1999, Argy, 2008). The expanded definition includes not only contractors, but also design consultants, building product manufacturers and facility managers. Viewing the construction industry as a product system provides a more comprehensive picture of the activities and actors that sustain Australia's built environment.

The Construction Product System is shown in Chart 1 which reveals the relationships between key activities and actors in the system. The regulatory and institutional framework shapes, and is shaped by, the supply network, project-based firms and projects themselves, with the technical support infrastructure playing a similar role. Many of the actors shown here are well known to industry analysts; actors like consultants, contractors, clients and distributors. Others are less often considered when the performance of the construction industry is analysed. These actors include financiers and insurers, for instance, who have an impact on the financial feasibility of innovations. If long-term positive environmental ramifications are not considered by these actors in return-on-investment calculations, then innovation may be constrained below the socially optimal level.

Other actors not always considered in industry analyses include educational institutions, R&D institutes and unions. Education institutions need to provide up-to-date training opportunities to match the demands of emerging innovations. R&D institutes, on the other hand, play a direct role in developing, co-developing, and/or testing innovations. The role of unions can be more problematic, with the multitude of unions within the industry potentially creating rigid labour boundaries that impede innovation implementation. Australia's federal political system exacerbates these problems through inconsistency and duplication, and is an extra challenge for the entire product system compared to a unified political structure.

Chart 1 usefully collects the actors and activities within the product system and provides background to our investigation of current challenges facing the system.

Chart 1: Activities and Actors in the Construction Product System



Source: (Gann and Salter, 2000)

2. Methods

Current challenges facing the above product system in Australia were assessed based on desk-top research comprising an international literature review. A panel of two researchers assessed the most highly cited industry and academic sources that focus on the built environment. Based on analysis of relevant articles, the two researchers independently created a list of key themes. The results were compared and the theme categories were rationalised manually. The challenges and innovations discussed in this paper comprise a rationalisation of those themes that were commonly listed by both researchers. The results are not exhaustive, but they do cover the main innovations offering environmental and productivity benefits in response to the main challenges identified.

The following types of sources were consulted in the literature review: construction management journals: e.g. Construction Management and Economics; general management journals: e.g. Research Policy; OECD reports: e.g. Environment Directorate; Industry surveys: e.g. Price Waterhouse Coopers (PWC); and government reports from Australia and the UK: e.g. Cole Royal Commission. The focus on the UK to inform Australian research is justified by the similar challenges facing the construction industry in both countries.

3. Current Challenges

Australia and the UK have undertaken numerous studies detailing the problems facing the industry (Gyles, 1992, CIDA, 1995, NatBACC, 1999, PWC, 2002, Cole, 2003, Fairclough, 2002, Egan, 1998, Latham, 1994, Strategic Forum, 2002). The problems common to both countries include fragmented production, lowest-cost tender selection, prescriptive specifications, inequitable risk distribution, and adversarial relationships. These and related issues have negatively impacted innovation rates, so that the incidence of innovation in the construction industry internationally compares poorly with other sectors, such as manufacturing (Reichstein et al., 2005). By broadly interpreting the construction industry as a system, Reichstein et al. (2005) were able to ensure a fair comparison, as recommended by Winch (2003). In the Australian context, research by PricewaterhouseCoopers (PWC) has found that the construction industry is slow to innovate, compared to other industries *and* other countries (PWC, 2002).

Persistently poor performance is also reflected in the fact that construction clients globally remain dissatisfied with typical project outcomes (Strategic Forum, 2002, Boyd and Chinyio, 2006). The answer to the industry's continuing problems is said to lie in building a stronger innovation culture to improve the rate and quality of innovation across the construction system (Hartmann, 2006b, Hartmann, 2006a). The industry appears to be moving in this direction, with an authoritative new book in Australia claiming that 'there has been a significant improvement in the level and quality of communication and collaboration between stakeholders which is yielding initiatives that promise to lift future performance' (Newton et al., 2009).

Such improvement was kick-started by the Action Agenda program in Australia, and the Construction Excellence program in the UK. In Australia, the Building and Construction Industries Action Agenda led to the formation of the Cooperative Research Centre for Construction Innovation, which has created a more positive innovation culture within the industry, through initiatives such as the BRITE Project (STEM, 2006). These beginnings need to be fortified over the long-term through ongoing government investment to correct continuing market failures such as uncertainty, asymmetric information, market power and spillover benefits/costs. These market imperfections result in innovation rates that are less than socially optimal. Despite some positive trends, government investment is particularly important at the present time because the industry currently faces a new wave of challenges, as detailed below:

1. Like many industrialised countries, Australia is currently grappling with the problem of a rapidly decaying built environment (Lewis, 2009). Substantial <u>infrastructure</u> investment is required to alleviate this situation and innovation in products and processes helps ensure maximum value-for-money.

2. Until the Global Financial Crisis hit Australia in 2008, the country had experienced the most sustained period of rapid economic growth ever witnessed (CEDA, 2005). This experience strained existing infrastructure (see Box 1) and underscored our <u>resource constraints</u> that hamper effective planning and construction of the built environment. Innovation helps manage the risks associated with resource shortages by delivering new ways of working smarter.

3. Globally, policy attention directed toward <u>climate change</u> and environmental sustainability by scientists, governments, industrialists and community groups has never been greater (OECD Environment Directorate, 2009). This creates challenges for reducing the impact of constructing and maintaining the built environment on the earth, requiring innovative solutions.

4. The increasing frequency of <u>weather-driven disasters</u>, such as floods and fires, creates the need for new ways of building that can accommodate weather extremes (Lindell and Prater, 2003). This need was underscored by the January 2011 floods in Australia.

Chart 2: Focus on Infrastructure

A crisis of inadequate Australian infrastructure in transport, energy, water, communication, health and education has emerged over the past 20 years (CEDA, 2005, Argy, 2008, DISR, 1999). A recent CEDA report identifies a ‘deep-seated infrastructure delivery problem’ stemming from declining real infrastructure investment nationally since the 1980s (CEDA, 2005). Despite other time series data showing a more positive picture (Coombs and Roberts, 2007, Marceau et al., 1999, Ruddock and Wharton, 2004), key commentators agree that Australia’s infrastructure stock is rapidly aging, compromising the economy’s productive capacity (BCA, 2007, Coombs and Roberts, 2007, CEDA, 2005). Engineers Australia claims that over the past 10-20 years, ‘there has been significant underinvestment in new infrastructure and that there has been insufficient attention to maintaining and renewing existing infrastructure’ (Engineers Australia, 2008, CIDA, 1995).

Recent changes of government at federal and state levels have seen policy shifts to a much more proactive stance on infrastructure investment, with massive programs recently being launched nationally, and across the states. Indeed, Australia recently experienced the early stages of an infrastructure boom (Potter, 2008), that has persisted in the face of the GFC shock due to extensive mining activity. The scale of expected infrastructure investment over the next 20 years is unprecedented in Australia’s history, resulting in significant challenges to efficient and effective delivery. Major capacity and cost challenges driven by rapidly escalating mining and construction activity have been experienced, and are expected to continue in the long-term despite the current turbulence in world financial markets. Although we face uncertain times, it is clear that in the long-run, Australia’s international competitiveness will require a significant boost to infrastructure spending. Against this backdrop, the effectiveness and efficiency of infrastructure projects is particularly critical. This is where innovation is critical – as a driver of improved project outcomes.

4. Innovative Responses

Given these challenges, innovative methods of constructing the Australian built environment have never been more urgently needed. The main underlying area in which innovation is required is in resource use. The idea that we have abundant natural resources, which once dominated economic thinking, is no longer useful. Acknowledgement of the finite limits to resource availability helps underscore the areas within the built environment where innovation will add maximum value. This is in relation to environmental sustainability. The literature review revealed that promising innovations are currently developing in two broad areas related to social and environmental sustainability: (1) design and planning innovations; and (2) material, equipment and machinery innovations. Chart 3 shows the sub-categories showing promise within these two areas.

Chart 3: Selected Innovations, Australian Sustainable Built Environment Industry, 2009

Sustainable Built Environment Innovation

DESIGN AND PLANNING INNOVATIONS

- **Virtual building design and information modelling**
  - 3D modelling
  - Construction Programming (4D)
  - Baseline quantities and costs (5D)
  - Direct fabrication
  - Asset Management
- **Off-site manufacture**
  - Just-in-time
  - Lean production
  - Concurrent engineering and design
  - IT-enabled planning
  - Time- and space-based scheduling
- **Green urbanism**
  - Sustainable communities
  - SlimCity
  - Urban informatics

MATERIAL, EQUIPMENT AND MACHINERY INNOVATIONS

- **Passive building technologies**
  - Passive lighting systems
  - Advanced insulation technology
  - Spectrally-sensitive glazing
  - Dynamic façade systems
  - Passive efficiency modelling
- **Sustainable products**
  - Energy Innovations
  - Material Innovations
- **Extreme weather-proofing technology**
  - Fire-retardant construction materials
  - Flooding and cyclone resistance
  - Disaster mitigation modelling
- **Control and monitoring systems**
  - Building management systems
  - Automated project performance control
  - Machine guidance technology

These innovations all have the potential to contribute in a significant way to meeting the four key challenges discussed above, by improving the efficiency and effectiveness of resource use. The expected impact of these innovations is described after taking into account the various dimensions of innovation, which are summarised in Chart 4. Our analysis commences with a definition of the term 'innovation'. Putting aside the plethora of definitions offered by individual authors from various industry and discipline backgrounds, the most authoritative definition is that provided by the OECD (2005) where innovation is considered to be a significant change in products, processes, work organisation or marketing methods. The changes may be new to the firm, sector or world. Chart 4 provides more detail concerning the OECD definition of innovation, and includes other authoritative views of innovation.

Chart 4: Key Innovation Typologies

Author(s)	Type of innovation is based on …	Categories of innovation
OECD (2005)	Output class	**Product** – good or service **Process** – production or delivery method **Marketing** – packaging, placement, pricing **Organisational** – internal business practices The intention is that these OECD categories are mutually exclusive and that they cover all possible types of innovation output by firms. Product and process innovation tends to be technical/ technological in character.
OECD (2005)	Degree of novelty	**New to the firm** – lowest degree of novelty – innovation adopted from within the industry **New to the industry** – innovation adopted from another industry **New to the world** – highest degree of novelty – previously unseen innovation – likely to be patented if technological in nature
(Harty, 2005)	Implementer's control	**Bounded** – innovation implementation can be contained within a single sphere of influence **Unbounded** – innovation implementation takes place in more contested domains
(Gopalakrishnan and Bierly, 2001)	Knowledge characteristics	**Tacit/Explicit** – codifiability, teachability, observability, articulateness **Systemic/Autonomous** – extent to which knowledge components are linked with other components **Complex/Simple** – sophistication of knowledge [last two dimensions reflect Slaughter 2000]
(Slaughter, 2000)	Change in knowledge and change in system linkages (System linkages first addressed by Teece 1986).	**Incremental** – small change in knowledge and small system impact **Architectural** – small change in knowledge and large system impact **Modular** – large change in knowledge and small system impact **System** – large change in knowledge from a combined set of innovations and large system impact **Radical** – large change in knowledge and new system
(Mitropoulos and Tatum, 1999)	Decision making (Similar to Winch 1998).	**Strategic** – continuous monitoring of ideas, thorough evaluation of options, top management participation, seeking to maximise benefits [proactive innovation] **Project** – solution-driven innovation, limited evaluation of available options, seeking to minimise consequences of failure [reactive innovation]
(Winch, 1998)	Source of idea	**Top down** – new idea adopted by firm's managers

		and implemented on projects [proactive innovation] **Bottom up** – new idea is the result of problem-solving on construction-sites, which may be later learned by the firm [reactive innovation]
(Rothwell, 1994)/(Powell, 1991)	Process	**Linear/Firm-based** – innovation process managed by a single firm **Interactive/Networked** – innovation process shared between firms
(Teece, 1986)	System linkages	**Autonomous** – little system impact **Systemic** – large system impact

Source: (Manley, 2008a)

The literature reveals increasing sophistication in the characterisation of different types of innovation, from simple distinctions between product and process innovation to more detailed categories along an expanding set of dimensions. The different views shown in Chart 4 help us to understand how the innovations in Chart 3 might address challenges facing the Australian built environment.

4.1 Design and Planning Innovations

These innovations all improve integration of the supply chain. Implementation is difficult due to their unbounded, systemic, networked and often tacit nature. These innovations embody the three output classes proposed by the OECD: product, process and organisational. This complex profile both hampers diffusion, and underpins the significant system wide benefits expected across the actors and activities in Chart 1. The rate of adoption of these innovations is rapidly increasing in Australia and the associated efficiency improvements are already improving resource use and environmental outcomes. Maximisation of benefits will depend on the strength of relationships between project-based organisations and the other critical system participants.

4.2 Material, Equipment and Machinery Innovations

These innovations can all be classed as product outputs. They are more autonomous in nature, compared to the design and planning innovations. Material, equipment and machinery innovations tend to be bounded, linear and explicit. This means that diffusion tends to be rapid. The impact of these innovations on the challenges faced by the Australian built environment tends to be incremental, although improvements in resource use and environmental sustainability are substantial over time. In terms of the actors and activities impacted by these innovations, diffusion tends to be driven by the supply network shown in Chart 1, with the support of technical and regulatory actors. Ultimate adoption depends on relationships with project based organisations and their clients.

5. Conclusions

The innovations listed in Chart 3 all have the potential to contribute in a significant way to meeting the four key challenges raised earlier, by (1) addressing the need for state-of-the-art infrastructure; (2) planning for resource shortages, including constrained supplies of skilled labour, energy and water;

(3) reducing our contribution to climate change; and (4) developing building innovations that resist fire and flood.

The construction industry needs to reinvent itself in times of challenging environmental and economic circumstances. The exploratory research discussed here examines possible responses for the Australian industry in terms of building innovations. The findings are likely to apply to most construction industries in developed countries because similar challenges are being confronted globally. Nevertheless, a limitation of this paper is its exploratory nature, which means that nothing can be said authoritatively about generalisablity. Future research is planned by the authors in order to examine the diffusion of the innovations in Chart 3, against the background of Rogers' Innovation-Decision process model (2003). That research is expected to contribute to theory by contextualising Rogers' model to take account of the peculiarities of the construction industry, compared to the manufacturing industry.

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A socio-technical network approach to the adoption of low and zero carbon technologies in new housing

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Abstract

Housing in the UK accounts for 30.5% of all energy consumed and is responsible for 25% of all carbon emissions. The UK Government's Code for Sustainable Homes requires all new homes to be zero carbon by 2016. The development and widespread diffusion of low and zero carbon (LZC) technologies is recognised as being a key solution for housing developers to deliver against this zero-carbon agenda. The innovation challenge to design and incorporate these technologies into housing developers' standard design and production templates will usher in significant technical and commercial risks. In this paper we report early results from an ongoing Engineering and Physical Sciences Research Council project looking at the innovation logic and trajectory of LZC technologies in new housing. The principal theoretical lens for the research is the socio-technical network approach which considers actors' interests and interpretative flexibilities of technologies and how they negotiate and reproduce 'acting spaces' to shape, in this case, the selection and adoption of LZC technologies. The initial findings are revealing the form and operation of the technology networks around new housing developments as being very complex, involving a range of actors and viewpoints that vary for each housing development.

Keywords: Low and zero carbon (LZC) technologies, socio-technical network approach (STNA)

1. Introduction

The United Kingdom (UK) has a commitment to reduce carbon dioxide (CO2) emissions by 34% by 2020 and 80% by 2050 (from a 1990 baseline) (DECC, 2011a). Housing in the UK accounts for 30.5% of all energy consumed (DECC, 2011b) and is responsible for 25% of the country's total carbon emissions (EST, 2008). As part of the Government strategy to reduce CO2 emissions from homes, the Code for Sustainable Homes and associated changes to Part L of the Building Regulations target of zero-carbon by 2016 (CLG, 2010; 2006) [1].

The development and widespread diffusion of low and zero carbon (LZC) technologies is seen as a key part of this drive to lower CO2 emissions from new housing. LZC technologies are defined, for the purposes of this paper, as 'a technology that can provide heating, cooling or power (or a combination of outputs) and will be powered solely by renewable energy (zero carbon) or powered in part by fossil fuels (low carbon)' (Bevan and Lu, 2012) [2]. Examples of a LZC technology include: solar photovoltaic, solar thermal, wind power, hydro power, heat pumps (ground/air/water), combined heat and power, biomass boiler, mechanical ventilation heat recovery and fuel cells (adapted from NHBC, 2010; SBSA, 2007; EST, 2010).

In addition to meeting the regulatory requirements, there is demand at a market level: developers need to consider home buyers' expectations and preferences of zero-carbon homes with LZC technologies. Element Energy (2008), for example, suggested that end-users are more concerned with the initial capital cost of the LCZ technology, as opposed to the long-term savings on energy that the technology can produce. Drawing on the transition management literature (Rip and Kemp, 1998), we argue that in order to understand the successful diffusion of LZC technologies in the new build housing sector, it is vital to understand the 'socio-technical regime' (Rip and Kemp, 1998) surrounding the uptake of the technology. This perspective considers the interactions, relationships and communications between the key actors (LZC technology manufacturers, the supply chain and end-users) involved in the uptake of LZC technologies, along with the influence of the surrounding regulatory and market demands.

Interim results from an Engineering and Physical Sciences Research Council and EDF Energy funded project in the UK are presented. Case study results from one housing development are reported which contributes to a better understanding of the answers to the following questions:

how and why do housing developers interact with LZC technology manufacturers and end-users, and how does this shape the strategy and practices of the housing developers and the incorporation of the technologies in housing designs?

how does the current market and regulatory context shape this interaction?

The structure of this paper is as follows. First, relevant literature on the theory underpinning the research, the socio-technical network approach, is described. Second, the case study methodology is given. Third, interim findings are presented. Finally, tentative conclusions are drawn.

2. Socio-technical network approach

The social-technical network approach (STNA) seeks to identify key actors and organisations and their different understandings and expectations of the new technology (Bijker et al., 1987). The socio-technical network (STN) is defined as “an analytic tool or method….distinguishing features include a focus on the interaction between social and material entities, and the practices through which they are developed and mobilized” (Schweber and Harty, 2010: 658). The central analytic concepts of STN include nodes, intermediaries, artefacts and interpretative flexibility (Elzen et al., 1996). Each element is defined below.

1. Artefacts

Artefacts can be material, a technology (physical) (e.g. roof tiles), social artefacts (e.g. the uptake of environmental assessment technologies such as Building Research Establishment's Environmental Assessment Method or somewhere between the two – virtual technology (e.g. the implementation of Building Information Modelling into firms).

2. Nodes

The term (relevant) node refers to those actors / social groups who actively influence the uptake of the artefact. Nodes in the network can be considered to be either individual human actors (e.g. designers, architects, contractors, occupiers) or (representatives of) groups of human actors (e.g. institutions, manufacturers).

3. Intermediaries

Intermediaries can be viewed as anything that passes from one actor (or ‘node’) to another (and vice versa), for example, speech, contracts, drawings, documents, conversations, money, information and so on. Nodes, therefore, can be seen as “processors of intermediaries” (Elzen et al., 1996: 103).

4. Interpretative flexibility

Interpretative flexibility refers to individual actors’ interpretation or meaning attached to a given artefact. Different actors may have very different interpretations of the same artefact. These differences may stimulate controversies and negotiations between the actors until (in an ideal situation) the technology and associated practices stabilises and closure is achieved.

3. Research methodology

The case study reported here used the STNA to better understand the relations between the principal actors (LZC manufacturers, the housing developers and the end-users), with a particular interest in the interactions which rotate around the development and use of LCZ technology.

The unit of analysis is taken as the ‘new housing development.’ Six case studies are being undertaken in the EPSRC-EDF project. Selection criteria for the six cases include type of unit (houses, apartments, mixed), type of housing (social / private / mixed housing), type of site (brown-field, green-field and regeneration), type of LZC technology (e.g. air source heat humps), the desired code level being achieved (e.g. Code level 3) and project progress (live and completed).

The data collection consisted of the review of relevant company documentation and semi-structured interviews. The interviews were carried through face-to-face or telephone with principal actors from each of the six new housing developments, including interviews with actors from the housing developer, its supply chain, and the occupiers of the housing. Before starting the interviews, a generic semi-structured interview protocol was prepared and pretested. Each interview was around one hour in length. The interview data was captured by note-taking and tape recording and then was transcribed verbatim. The transcripts were made anonymous before coding and sent to the interviewee on request.

4. Interim Findings

4.1 Description of case study

This paper will focus on one of the six cases. The chosen case is a small private housing development of twenty-six houses in South East England. The LZC technology being used is the air source heat pump (ASHP). The ASHP is mounted on the side of each house and is the only source of heating and hot water. The site is green-field and has achieved a Code level 3 standard [1]. A particular feature of the site is that on its curtilage there are two listed buildings: a Grade 1 listed church and a Grade 2 listed barn. The findings are based on eight semi-structured interviews which were carried out with one technical director, one technical co-ordinator, one site manager, one designer, and two occupants.

4.2 Housing development socio-technical network (STN)

Figure 1 illustrates the housing development’s STN. The research findings indicate there are eleven principle actor groups within the new housing development process. This paper will focus on the interaction between local authority planner / conservation officer and housing developer technical team.

4.2.1 Principal actor groups

1. Housing developer (HD) technical team (technical and design): is responsible for the design and planning of the development and compliance with the planning, Code for Sustainable Homes and Building Regulation requirements.

> Technical director: manages the technical team: design of the development and compliance with the Building Regulations, Code for Sustainable Homes and the planning requirements.

Technical co-ordinator: co-ordinate the development in terms of the design, planning, Buildings Regulations.

2. Local authority (LA):

Planner: sets planning requirements and grants planning permission, subject to these requirements being met.

Conservation officer: ensures that the planning requirements are sensitive to the aesthetics and materials of the bordering Grade I listed church and Grade II listed barn.

4.2.2 Principal interests

The research results indicate that both actor groups had their own set of interests when interacting with each other within the new housing development. It was found that the planner's principal interest was to ensure that the housing developer 'complied with requirements determined by the aesthetic and material properties of the listed buildings. The Technical Co-coordinator, for example, explained the involvement of the conservation officer as follows:

"The problem we had here was that the site, although it's not in a conservation area, actually has a Grade II listed barn on it, but just here to the south of the site is a Grade I listed church. So, rightly or wrongly the Conservation Officer got involved with the project"

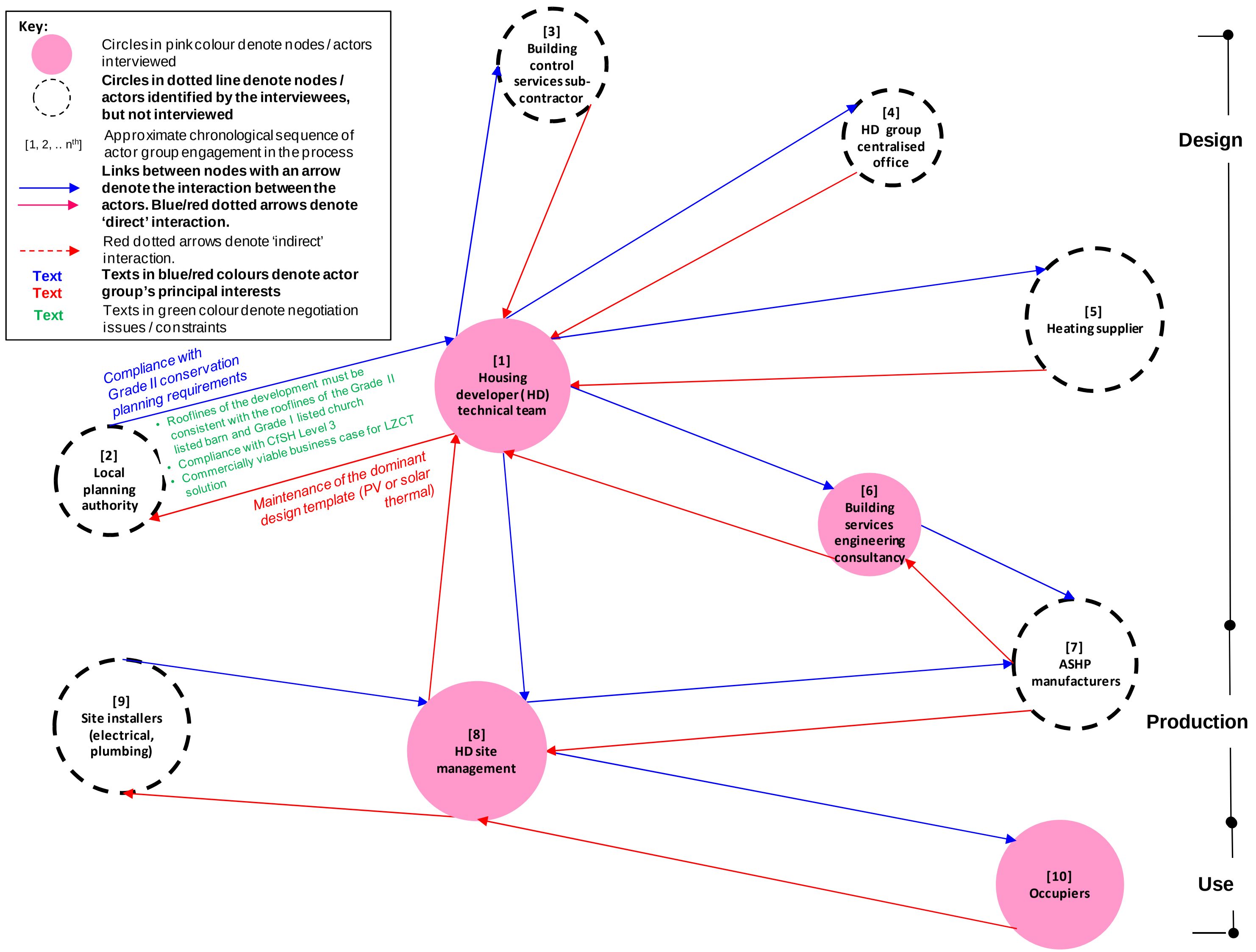

Figure 1 An example of a housing development socio-technical network

The Technical Director went on to argue that:

"Because of the conservation element of it … and this is Case 2, now it's conservation and because we had to take a certain form, you didn't have the opportunity then to play around with the roofscapes, so we couldn't get a more south facing or south west."

4.2.3 Key negotiation issues

It appears there are three key negotiation issues / constraints occurred during the interactions. First, there was a planning requirement that the rooflines of the development must be consistent with the roofline of the two listed buildings. The Technical Co-coordinator, for instance, stated that:

"The overall concept of materials, applied to the whole of the site, but in particular these ones, because they overlook the roof tiles and the bricks and the window, and the detailing, he treated it as a conservation area, rightly or wrongly. One of the problems with that was that with these plain tiles and the fact that it was overlooking the listed buildings."

The driver for the use of ASHP was due to the site being adjacent to a grade II conservation area and a grade I listed church. This view is supported by the Technical Director, in his observation that:

"The main driver here was … we were adjacent to a conservation area and the listed church…"

It is clear to see that the planner not only had input into the technology selected, but also various other characteristics of the site, such as the type of materials used within and around the properties (roof tiles, windows). Originally the developer planned on installing 'solar thermal' at the site which is normally with they do within a Code 3 development. This technology however was rejected by the planner due to the conservation area and listed building requirements. This is evidenced by the Site Manager, noting that:

"being Code 3 here, which I don't think it was when we originally set it out, it became Code 3, they said, "Oh, so you're Code 3 you're going to have to do another form of heating." So [planners] said, "Okay, we don't want the solar panels because they're going to be on the road front, so, what's the options?" And [ASHP] was one of the options which we'd been looking at, anyway."

Second, meeting Code 3 was recognised as a key issue. The Technical Director explained the choice of ASHPs was to meet Code 3 by stating that:

"we decided that we would go for air source heat pumps, because of Code 3. The whole site is Code 3, so we looked at air source heat pumps as an alternative to our normal gas central heating systems."

Finally, the housing developer had an interest to ensure the project met the code-level requirements within the budget of the firm. The Technical Co-coordinator, for example, described that:

“We need those to get the credits, because it’s – because of the constraints we have on costings, we need to gain credits where we can, by using such technology with the solar panels, the PV units…”

5. Discussion and conclusions

The findings, when viewed through social-technical network approach (STNA), bring into the sharp focus two key, interrelated issues. First, two very distinctive interests of each principal actor groups were identified. The overriding interest of the housing developer was to maintain its standardised LZC solution of solar thermal technology to maximise economies of scale and the efficiencies of repetition. The countering interest of the planners for the development to be sympathetic to the aesthetic and material properties of the listed buildings displaced the developers’ interest, resulting in the use of ASHPs. The negotiation or acting space through which these interests were played out indicated that each actors held very different interpretations (or interpretative flexibility) of LZC technologies. The housing developer constructed meaning in terms of the technologies’ fundamental technical and economic attributes (for example, see Lees and Sexton, 2011). In contrast, the planners interpreted LZC technologies through the prism of how they can meet a diverse range of requirements, such as social and aesthetics, which go beyond the housing developers technical and economic concerns.

Second, this exploratory paper has mobilised the STNA to construct a better, albeit partial, understanding of why and how a new LZC technology (in this case ASHPs) is adopted within housing developments. The approach recognises and distils the driving interests of actors and the acting spaces through which these interests are negotiated and, ultimately, shaped or displaced through the process.

6. Notes

[1] The Code for Sustainable Homes (the Code) is key governmental measure providing guidelines and a sustainability rating for new build homes; each new home being given a code level from 1-6. Currently it is mandatory that all new homes have a code rating. The Code is assessed against nine categories which are energy and CO2 emissions, water, materials, surface water run-off, waste, pollution, health and well-being, management and ecology (CLG, 2010). The aim of the code is for every new home to achieve a zero carbon classification by 2016 (CLG, 2007). It is not required that house builders achieve a particular level of the Code unless developers are producing social housing, developing on ex-public land or there is a condition set within the planning permission of the development. However, Part L Building Regulations, a compulsory requirement, is changing in-line with the Code; meaning that compliance with the Building Regulation results is an achievement of a level within the Code for energy and carbon dioxide emissions of the property.

[2] A more detailed discussion on the definition of LZC can be found in Bevan and Lu, (2012).

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Low and zero carbon technologies use in the UK housebuilding industry

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Abstract

The UK has set a target for a reduction in CO_2 emissions by 80% by 2050 compared to 1990 levels. 25% of UK emissions are generated through demand for heat and electricity in homes. In order for housebuilders in the UK to contribute to the carbon reduction targets they will need to transform the environmental performance of the units that they produce. The transformation will require system-wide innovation and change comprising new technologies, new markets and new institutional supporting systems. There is need for research to better understand, and therefore, steer this system innovation. The research reported here contributes to this need by addressing the impact of the growing raft of environmental regulations on the UK housebuilding sector. The focus is on the uptake of low and zero carbon (LZC) technologies within the sector. This research reports on a web-based survey to explore which technologies are being adopted and which, if any, of these technologies are likely to assume a dominant position as the 2016 zero carbon homes target looms closer. The survey shows that the UK housebuilding industry currently relies heavily on solar based technologies and mechanical ventilation and heat cover systems. The indications are that the reliance on solar technologies is likely to continue.

Keywords: Low and zero carbon technologies, housing, innovation, dominant technology

1. Introduction

From 2016 onwards all new homes built in the United Kingdom (UK) will be required to be zero carbon. This requirement is an important part of the UK Government's strategy to reduce total carbon emissions by 80% by 2050 (DECC, 2008). It is being implemented in line with the Code for Sustainable Homes (the Code) through changes made to Part L of the Building Regulations (DCLG, 2006). The Code, and particularly the zero carbon requirement from 2016, is potentially poses a significant innovation challenge to the UK housebuilding industry which has been tasked to deliver homes with enhanced environmental performance.

In order to satisfy the enhanced environmental performance demands of the new Building Regulations many housebuilders are incorporating low and zero carbon (LZC) technologies into the homes they produce. There is a wealth of literature exploring the technical potential of individual technologies, or combination of technologies, which often concludes with a prescriptive, normative type conclusion of which technology is 'best' and 'should' be used (Boardman *et al*., 2005). There is also research reporting on how the Code has developed and how this may affect the housebuilding industry (Goodier and Pan, 2010). Neither of these streams engage with the important question of which low and zero carbon technologies are selected by housebuilders.

Dominant technologies emerge through the interplay between radical and incremental innovation (Tushman and Anderson, 1986). Incremental innovation tends to be the gradual development of performance and/or cost features of an existing, say, technology which buildings upon the skills and competences which exist within the housing developers and their supply chains. In contrast radical innovation brings a whole new technology to bear with significantly changed performance and/or cost attributes which often require new skills and competencies. The Code energy / CO_2 requirements are demanding the use of LZC technologies which may necessitate radical innovation within housing developers.

Technical performance is an important influence on which LZC technology is selected by housebuilders and compliance with the Building Regulations. However, the selection of a technology does not occur in a vacuum nor is it disconnected from the business model and capability set of the housebuilder. In selecting a LZC technology housebuilders navigate a complex environment of potentially conflicting interests. Myriad different 'ingredients' can feed into the decision of which technology to select and this decision may not rest with one actor, but be the results of distributed decision making. Further, not all of the processes that could enable or constrain the selection of a LZC technology are within the control of the housebuilder, in particular planning requirements. The complexity of this selection process may lead to the adoption of LZC solutions than when considered from a purely technical basis appears 'sub-optimal'.

This paper reports on the results of a web-based survey to identify which technologies are being used; rather than the prevailing normative position taken in the literature. A range of different principles which may influence the uptake of LZC technologies are explored. The paper is structured in the following way. A brief introduction to context of the Code and the UK housebuilding industry is given which is followed by a description of the methodology used for the web-based survey. The overall findings from the survey are presented along with a discussion of the potential implications for housebuilders. The paper concludes with a summary of the key findings and a recommendation for future work.

2. The Code and UK housebuilding

The context for this research is which new technologies are being selected by housebuilders in response to the demands made by the Code. The following sections contain a brief introduction to the Code and to the shape and size of the UK housebuilding industry.

2.1 The Code for Sustainable Homes

The Code was introduced in 2006 and lays down a timeline for homes to conform to higher levels of environmental performance, with the energy requirement enforced through a progressive changing of Part L of the Building Regulations. The Code is assessed against nine areas (DCLG, 2010). These areas are:

- energy/CO_2
- pollution
- water
- health and well-being
- materials
- management
- surface water run-off
- ecology
- waste

The Code uses a 6 level rating system. Each level of the Code has a point threshold which must be reached. How developers achieve the threshold is flexible but there are minimum standards for each of the Code levels in the energy/CO_2 and water areas and minimum standards at entry level in the material, surface water run-off and materials areas. These levels are indicated both as a percentage reduction on Part L (conservation of fuel and power), 2006 Building Regulations (DCLG, 2008), or target emission rate, and as an absolute carbon compliance limit (ZCH, 2011), as shown in Table 1. In the UK compliance with the Building Regulations is mandatory. Current 2010 Part L Building Regulations satisfy up to, and including, Level 3 of the Code relating to CO_2 emissions.

Table 1: CO_2 emission reduction targets as set out in the Code relative to the target emission rate based upon 2006 Part L Build Regulations

Code Level	*Minimum percentage reduction in dwelling emission rate over target emission rate*	*Carbon compliance (kgCO2/m2/pa)*
Level 1 (★)	*10*	*24*
Level 2 (★★)	*18*	*22*
Level 3 (★★★)	*25*	*20*
Level 4 (★★★★)	*44*	*14*
Level 5 (★★★★★)	*100*	*0*
Level 6 (★★★★★★)	*'Zero Carbon' Home*	*-20*

Level 5 refers to a dwelling which has zero regulated CO_2 emissions (space heating, lighting, white goods, and so on) whereas Level 6 refers to a dwelling which actively mitigates the regulated emissions plus those from the unregulated 'plug load' (for example, televisions, radios, computers).

2.2 The UK housebuilding sector

The UK has one of the most concentrated house building sectors with a small number of very large 'volume house builders' producing over half of the units produced per year (Ball, 2008). This is likely to have become further concentrated during the period of recession which has been experienced since the global financial crisis. These large volume developers base their business models on relatively standardised procurement, design and production routines. Compliance with the Code will require new solutions which may well be in tension with their well established set of practices. This tension is causing uncertainty for housing developers and is bringing into sharp focus the question: how do they respond to the Code in an effective and efficient fashion?

One major aspect of uncertainty surrounding the delivery of new low carbon homes is the selection, incorporation and use of LZC technologies. Developers are unsure of which technologies are likely to become dominant across the housing sector (and therefore legitimate in the eyes of key actors, such as planning authorities and home buyers).

Housing developers are faced with a number of scenarios which are, as yet, not fully clear. The least disruptive scenario is for housing developers to 'bolt-on' new LZC technologies to mainly unchanged housing designs ('incremental innovation'). The most disruptive would be an introduction not only of new LZC technologies but a significant change in housing developers' overall business models, designs and production processes ('radical innovation'). It is this broader innovation perspective which underpinned the design of the survey methodology described in the next section.

Whilst the lower level of the Code can be met through enhanced fabric or bolt-on technologies it is likely that the higher level of the Code will require a more integrated approach between the fabric and the LZC technologies. This may place further strain on the standardised processed that the housebuilders rely upon.

3. Methodology

The development and execution of this research has been underpinned and defined by a process of co-production between industry and the research team. Throughout this work the research questions, aims and methods have been jointly guided by input from the research staff and from senior representatives within the UK house building sector.

An exploratory, web-based survey approach was used to examine which technologies are being used in different circumstances and to interrogate factors which may influence the selection, or not, of LZC technologies. The design of the survey drew upon Rogers' criteria for the uptake and diffusion of new technologies (1995, p.14). These criteria, relative advantage, compatibility, complexity, trialability, and observability were adapted for the context of LZC technologies in new build housing.

The survey contained 51 questions, both open and closed, to establish current use of LZC technologies. The LZC technologies selected for this study are those identified in the NHBC review of microgeneration and renewable energy technologies (NHBC, 2008). The effect of site type (greenfield, brownfield and conversion), dwelling type (house, apartments and mixed) and location on which technologies are selected was investigated.

The survey was distributed through the industrial partners' mailing lists to those members who had expressed an interest in sustainability. Respondents participated through self selection by responding to an e-mail invitation to take part in the survey. This sampling strategy has the potential weakness of not being representative of the wider population but is suitable, in cases like this, for exploratory research. For this research it was key to reach the sections of the house building sector that are using LZC technologies as their experiences of the technologies are vital in understanding the rationale for selection of the technology.

The survey captured a wide range of views from different parts of the sector, including large and small house builders (both in terms of number of employees and units built per year), different regions in the UK, different job roles and different levels of seniority. Overall response rates to the survey were low. A number of responses came from individuals not actively involved in producing homes. These individuals were not allowed to complete the survey. The survey was distributed to approximately 12,000 potential participants and 62 usable responses were. Usable responses were those from respondents who were actively engaged in the production of housing and completed the full survey. This is a response rate of less than 1%. This would be a significant challenge if we were deploying a representative sampling strategy but is not a significant difficulty when using a purposive strategy. Through this paper any discussion relates to within the sample set and we do not generalise to the wider population.

4. Findings

A significant proportion of those that responded to the survey identified with the job roles of 'design' or 'construction'. Those who responded to the survey tended to come from small companies, which were active in a small number of geographical areas, or large companies, whom operated nationwide. Table 1 breaks down the respondent so that it is possible to identify the numbers who responded to the survey by job type and geographical footprint of the company they work for. The composition of the sample set arguably reflects the fragmented, project-based nature of the housebuilding sector in the UK. Like other elements of the construction industry in the UK, the house building industry is dominated by a small number of large firms who use smaller, local companies as part of their supply chains. Those who responded to the survey came from across this range and from across the design and construction process.

Table 1: Job role of respondent against the number of regions in which the company they work for develops

Geographical footprint (Number of regions)							
Job role	***1-2***	***3-4***	***5-6***	***7-8***	***9-10***	***11-12***	***Total***
Design	*12*	*4*	*2*	*-*	*-*	*4*	*22*
Construction	*9*	*2*	*-*	*1*	*2*	*4*	*18*
Other	*5*	*2*	*-*	*1*	*1*	*1*	*10*
Management	*7*	*1*	*-*	*-*	*-*	*-*	*8*
Sales	*1*	*-*	*-*	*-*	*-*	*2*	*3*
Total	*34*	*9*	*2*	*2*	*3*	*11*	

A key question is this research is which technologies are being used by housebuilders? For three different site types and for a range of different unit types, respondents were asked to identify which technologies they currently use for that site/unit combination. As different numbers of respondents developed on each of the site-unit combinations 'technology use' is expressed as a percentage of those who develop each of the site-unit combinations and use a particular technology. Table 2 shows the number of respondents that develop each of the unit types for the three different site types identified. Greenfield sites are defined as sites that have had no previous development, brownfield sites are defined as sites which have had development but all structures have been removed before development, and conversion sites are defined as sites that have an existing structure some element of which is being retained in the new buildings.

Table 2: The number of housebuilders who produce the different unit types on the three site types.

		Site type		
Unit type		***Greenfield***	***Brownfield***	***Conversion***
Houses	*Terraced*	*38*	*52*	*10*
	Semi-detached	*43*	*48*	*10*
	Detached	*46*	*51*	*17*
Apartments	*Up to and including three floors*	*34*	*52*	*20*
	Above three floors	*18*	*34*	*15*

There was a clear difference in how many of the sixty-two housebuilders currently used the different LZC technologies. Four of the technologies (wind power, fuel cell, absorption heat pumps and small scale hydroelectric systems) were used by less than ten percent of the housebuilders. Three of the technologies (solar thermal, solar photovoltaic and mechanical ventilation and heat recovery systems) were used by more than sixty percent of the house builders. The remaining five technologies ranged from approximately twenty to fifty percent. Figure 1 show the range of use of each of the technologies.

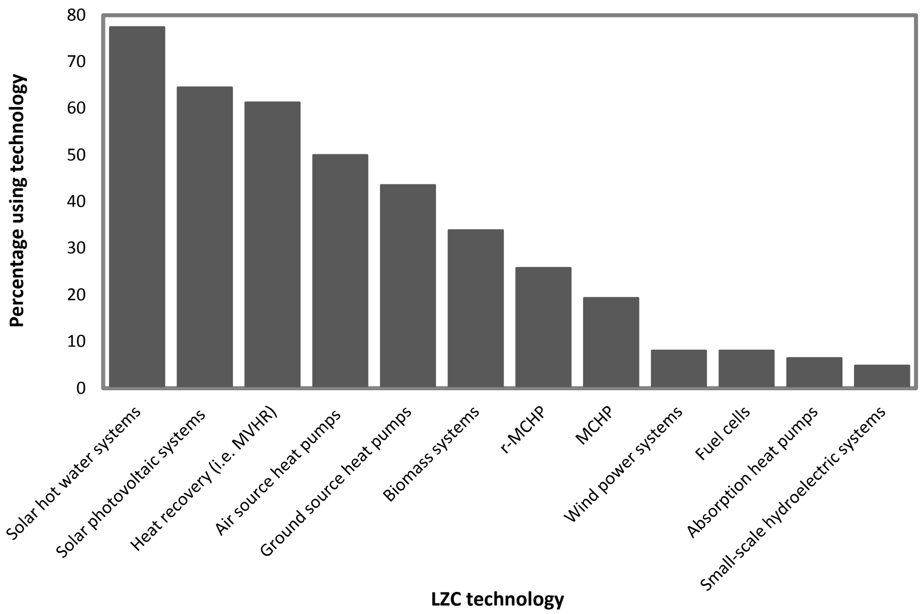

Fig. 1: The percentage of housebuilders that use each of the low and zero carbon technology (n = 62).

The housebuilders who responded to the survey were very clear which LZC technology they expected to play the most significant role in achieving the 2016 targets. Each responded was asked to identify which technology they expected to be the most important. Almost three-quarters of respondents indicated that a solar based technology (photovoltaic or solar thermal) would be the most important with over half indicating that photovoltaic systems would be the most important. This data is sown in Figure 2 in which it is clear that consensus rests with the solar based technologies.

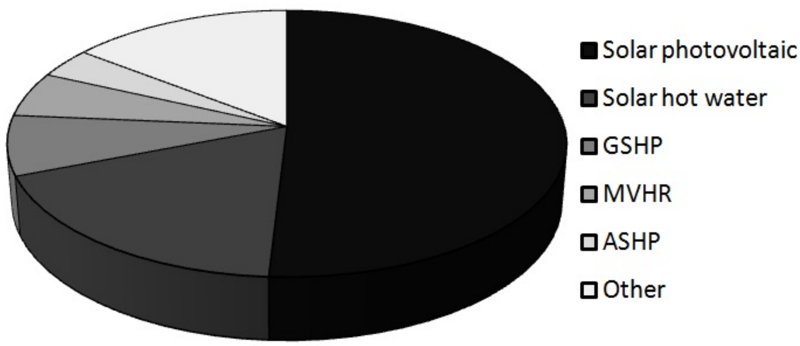

Fig. 2: The percentage of respondents that indicate which technology will play the most significant role in the house building sector's move to zero carbon.

4.1 Implications for UK housebuilders

The sources of CO_2 emissions from the home are not evenly distributed. Typically 55% of the emission emanate from space and water heating, 28 % from appliances and the remainder from cooking, lighting, pumps and fans (NHBC Foundation 2009). The challenge of reducing emissions resulting from space and water heating are distinct from those of reducing emissions from the other sources and the strategies for tackling them are correspondingly different (Zero Carbon Hub, 2010). Emissions from heating water and space can be reduced through better specified materials, improved workmanship in the construction of the dwelling and more efficient boilers. They can be further reduced by the use of LZC technologies. Once emissions from heating have been reduced offsetting the emissions stemming from the other sources, and any remaining emissions from heating, relies on the active generation of energy on- or off-site. The results of this survey show that UK housebuilders are relying on the production of this energy through the use predominately of solar-based technologies.

The potential for onsite generation at a dwelling level depends strongly on dwelling type. This is particularly true for solar-based technologies. For example, the use of photovoltaic cells to generate electricity depends significantly on, among other factors, the area of roof space available per unit. This area is much higher (for each occupant) in detached houses than it is in high rise apartment blocks. Correspondingly the ability to generate high levels of energy per occupant from solar-based technologies is higher in detached houses that in apartment blocks. In fact, evidence is already growing to show that for the 2013 and 2016 changes to the Building Regulations solar-based technologies may not be sufficient to generate the levels on energy required for compliance (Zero Carbon Hub, 2011).

5. Conclusions

The survey has indicated that solar hot water systems, solar photovoltaic systems and mechanical ventilation and heat recovery technologies are, on aggregate across housing types, are the most dominant. The dominance of these technologies is accentuated with houses. It is easy to extrapolate this trend and conclude that these technologies will become the sector norm. We are more cautious. The potential moderating effects of the ongoing specification of the Code for Sustainable Homes, along with the progression to Level 6 on 2016, introduces uncertainty. Current solutions may not be sufficient to comply with future requirements. The potential implications of this may be profound, with housing developers committing to improvised standard design templates which do not recognise that actual scale and scope of innovation required. Future research, therefore, needs to be undertaken to track the shifting drama of housing developers' responses to zero-carbon. This should take the form of periodic surveys, such as this, as well as triangulating the results with longitudinal case studies.

6. Acknowledgements

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Implementing Code for Sustainable Homes (CSH) Level 6 in the UK's social housing sector

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Abstract

In order to mitigate the impact of climate change on the environment, the UK government introduced the Code for Sustainable Homes (CSH) to guide house builders design and construct houses sustainably. The target is by 2016 all the new houses have to reach the highest of the CSH Level 6, i.e. "Zero carbon home". In light of this target, this research aims at investigating how to effectively implement Code 6 in the social housing sector. Social housing sector is selected because it counts about half of the new net added house units each year in the UK and the majority of the social housing projects are through public funding so they have the obligation to take the lead in meeting this target. Based on an extensive literature review and a semi-structured interview with practitioners (including architects, project managers, housing association managers and planning officers) who have been involved in social housing projects implementing CSH Level 6, this research found that the definition of the "Zero carbon home", though key to the achievement of Code Level 6, is in itself a barrier and 80% of the houses to be built will not be able to achieve the required standards. A culture change among the stakeholders is needed in order to wholeheartedly embrace the concept of sustainable construction so alternative house design and construction can be incorporated into the building process. The low carbon technologies are still too expensive and with limited choices, and not many sustainable materials can be sourced locally. But the experience gained from building lower level of CSH can prepare well the practitioners for Code Level 6 projects. Besides the various incentives from the government, clients / end users need be made aware of the benefits of this sustainable housing through reduced energy costs throughout the life cycle so that they will demand more sustainable development.

Keywords: Code for Sustainable Homes, Level 6, sustainable construction, social housing sector

1. Introduction

There has been growing concern of the impact humans and their activities are having on the environment (Pugh, 1996; Grubb *et al.*, 1999; Phillips, 2003; Wheeler, 2004). Finding ways of mitigating the impact of climate change became the focus of the international community in order to sustain the growing global population. This led the European Union (EU) to set targets for its member states (Victor, 2001), which left the UK government with no choice but make a strong commitment to cutting its CO_2 emissions by 60% by 2050 with real progress by 2020 (Grubb *et al.*, 1999; McEvoy et al., 1999; Theobald and Walker, 2008). The construction industry was identified as being a major energy consumer. Activities within the industry were said to be responsible for the consumption of between 50% - 60% of the energy and about 46% of UK's CO_2 emissions come from buildings (Raynsford, 1999; Uher, 1999; Morton, 2002; Phillips, 2003; Dimitrijevic and Langford, 2007). The only way for the UK government to meet its ambitious target was through sustainable development.

One of the policies introduced by the UK government is the Code for Sustainable Homes (CSH). The CSH was first introduced in 2007 as a voluntary scheme for publicly funded housing projects. Its purpose was to be a pathway to achieve improved environmental performance for new homes by setting out minimum requirements that would help guide house builders on how best to design and construct homes sustainably (Al-Hassan, 2009; Osmani and O'Reilly, 2009; McManus *et al*., 2010; STuDS, 2010). It was developed by the government in close collaboration with the Building Research Establishment (BRE) and the Construction Industry Research and Information Association (CIRIA) in consultation with most of the industry's stakeholders (DCLG, 2006).

As an environmental assessment tool, the CSH identifies nine key focus areas that are known to greatly impact on the environment and set out measures of how these can best be mitigated (DCLG, 2008): *Energy and CO2 emissions; Surface water run-off; Water; Materials; Waste; Pollution; Health and well-being; Management; and Ecology*. The CSH is split into 6 ratings from Level 1 to Level 6, with Level 6 being the highest standard representative of a "Zero Carbon Home". It is the government's intention that Code Level 6 becomes mandatory for all housing projects from 2016 (DCLG, 2009; Osmani and O'Reilly, 2009; STuDs, 2010).

The CSH allows some flexibility and the responsibility lies with the developers to carefully consider which of the nine categories are practically achievable so as to obtain the necessary credits required. Despite this, there is a minimum standard at *each level* of the code for the Energy / CO_2 Emission and Water categories, a minimum standard at *code entry level* for the Materials, Surface water run-off, and Waste categories, but no minimum standard for the Pollution, Health and wellbeing, Management and Ecology categories (DCLG, 2008).

The social housing sector undertakes the main responsibility of providing affordable housing. Among the 121,200 net additional housing units in England in 2010-11, half of them (60,630) are social housing (DCLG, 2011a and 2011b). As a large proportion of social housing is public funded, they should take the lead in sustainable development. Hence, the social housing sector has been the focus for a lot of the policies that would enable meet government's sustainable development target. Although most of the social housing projects are now built to CSH Level 4 standard, there are a number of challenges when it comes to meeting the requirements of Level 6. There is a big jump in the number of points currently required by Code Level 4 (68 points) to those of Level 6 (90 points), entailing much more stringent requirements. Building sustainably requires the use of low carbon technologies, which is still very expensive, making it less affordable and viable (Halliday, 2008; Roberts and Sims, 2008; McManus et al., 2010). This is of great concern to most of the stakeholders especially clients and developers who have to bear the cost yet are very profit driven (Morton, 2008). Moreover, developers and house builders need the necessary knowledge in order to make cost decisions relating to sustainable development (Carter, 2005).

Table 1 Levels of the CSH (DCLG, 2007)

Code Level	*Number of points required (including minimum standards)*	*Percentage reduction in CO_2 emission over Part L of the Building Regulations*
1 (*)	*36*	*10%*
2 (**)	*48*	*18%*
3 (***)	*57*	*25%*
4 (****)	*68*	*44%*
5 (*****)	*84*	*100%*
6 (******)	*90*	*Zero Carbon Home*

The definition of "zero carbon home", as required for Level 6, has attracted heated debate because different people have different interpretation (Guy, 2007; McManus et al., 2010). According to the DCLG (2006, pp 7), a zero carbon home refers to "zero net emissions of carbon dioxide (CO2) from all energy use in the home". With this definition, 80% of new homes would not be able to achieve CSH Level 6, so the definition itself becomes a key barrier (Brook, 2009). But there are other similar definitions, including *zero carbon* (i.e. no carbon-emitting fuels are burnt on site and no electricity is imported from the grid), *net zero carbon* (i.e. carbon-emitting fuels are burnt on site, but locally generated renewable energy is exported to the grid to make up for it), and *carbon neutral* (i.e. offsite generated renewable energy is imported from the grid or via private wires) (Guy, 2007), which may be more practical.

Most of the previous researches have focused on the technical aspect of the CSH i.e. amount of emission rate for a Code 3 house, carbon footprint analysis of levels 4 and 5 etc. Very little research has been conducted with regards to finding out how to practically achieve the CSH requirements on constructions sites. By studying the perceptions and experiences of the practitioners involved in social housing pilot schemes in implementing Code Level 6, this research aims at investigating the challenges faced and the solutions adapted in practice and exploring ways of effectively achieving Code Level 6 in the social housing sector.

2. Research methodology

This research takes a qualitative approach because a lot of issues investigated are neither quantifiable nor comparable and the research findings will be mainly based upon practitioners' experiences, views and insights. Based on extensive literature review, semi-structured interviews were conducted to collect primary data. Semi-structured interview allows open-end questions to be asked so that the practitioners' experience and insights can be fully explored (Knight and Ruddock, 2008), and the responses from different key stakeholders can be compared and contrasted so that the complexity of the research subject can be understood from different perspectives.

To ensure the data collected from the interview is robust to address the research question, the respondents should have not only a good understanding of Code Level 6 and the relevant technical knowledge, but also direct experience in implementing it in social housing projects. As Code Level 6 will not become mandatory until 2016, there are very few projects that have been built to this high standard and practitioners available for this research are rather limited. The respondents were selected from two Code Level 6 pilot schemes, one in Northampton and the other in Birmingham, due to their geographical proximity to the researchers. In total, eight respondents were selected from across the different professions, all of which were involved at different stages of the pilot schemes. Although the size of the samples is relatively small and therefore not necessarily representative in terms of the experience, project type and location, this research does produce a useful snap shot on how the Code Level 6 is being implemented in social housing sector. Each stakeholder plays a different role at various levels of the projects hence they need to be included as part of the research sample. Among them, clients provide the funding for the projects, are involved at all levels of the project and are the key decision makers. Architects need to design the project up to the Code Level 6 standard. Planners are essentially involved in assessing and granting the planning applications and contractors are responsible for constructing the projects and ensuring that the standards for Code Level 6 are practically met. Table 2 shows the details of the respondents in this research.

3. Data collection

Most of the interviews were conducted face-to-face at the respondents' work places, except the two interviews with the planning officers, which were done on telephone due to the respondents' time restraint. On average, each interview lasted about 30 minutes and was recorded with the permission of the respondents. During the interview, the respondents were asked their knowledge and awareness of Code Level 6, how they implemented it in their projects, the problems met and how they were dealt with, and what should be done to promote this standard in the social housing sector as well as in the construction industry. In this section, the primary data collected from the interviews are presented.

Table 2 Respondents

Respondent	*Job Title*	*Project involved*
A	*Architect*	*Northampton*
B	*Contractor's Commercial Manager*	*Northampton*
C	*(Housing Association) Development Project Manager*	*Birmingham*
D	*Contractor's Senior Project Manager*	*Birmingham*
E	*Planning Officer in local council*	*Birmingham*
F	*Planning Officer in local council*	*Birmingham*
G	*Contractor's Development Manager (Architect)*	*Northampton*
H	*(Housing Association) Head of Project Development*	*Birmingham*

3.1 Knowledge of Code Level 6

Respondents B and D admitted that they had no knowledge and understanding of Code Level 6 prior to their involvement in the pilot schemes. While respondent B claimed there is no need of having background knowledge and understanding of Code Level 6, C insisted that a good understanding of the sustainable development and Code Level 6 helps create a certain level of appreciation of how building sustainably fits into the bigger picture. Being the planning officer at the local council, respondents E and F also admitted that they only had knowledge as far as the fact that Code Level 6 is a higher level of the CSH. This causes great concern as they are supposed to give planning permission and enforce building regulations but feel incapable of advising applicants in matters relating to sustainable construction due to lack of training. On the contrary, respondents A, G and H, who all have architectural backgrounds, seemed to have the technical knowledge of Code Level 6 and understood the steps leading up to its implementation. Because they have been involved directly or indirectly in the design of houses on a number of projects that were built to the Code Level 6 or any of the lower codes, they appeared more appreciative of the government's intention to introduce the Code Level 6 to meet the climate change challenge.

Interestingly, in both projects the idea of Code Level 6 was not the clients' original intention but instigated only during the construction phase. In the Northampton project the idea was initiated by the Architect more as a PR exercise and then sold to the client who was more than happy to fund it. In the Birmingham case the client thought they could market themselves better by incorporating units to Code Level 6 when the project was already underway, again another PR exercise. Not surprisingly, from a contractor's point of view, respondent B claimed that the Code Level 6 standard only complicated their work because they did not view the scheme as one that was looking to build sustainably in order to save the environment.

3.2 Definition of Zero carbon and 2016 target

CSH defines Code Level 6 as "Zero carbon home". Respondents B, E and F had no knowledge of what a "zero carbon home" entails. Other respondents (A, C, D, G and H) believe it is difficult, if not impossible, to achieve in its current definition. Respondent C remarked:

"*regardless of what you do, you can never avoid the emission of CO_2*".

The main reason was that the process of fabrication, manufacturing and transportation of materials unavoidably produces a certain amount of CO_2. When referring to the definition relating to sites being able to generate their own power through renewable sources or even exporting to the grid, respondents G and H believed that the social housing sector has not yet reached the stage where sites are able to support their operations without importing energy from the grid. On the other hand, respondent D claims it is possible to achieve Code 6 using *carbon neutral* as opposed to the current definition "zero carbon home" by the government.

Most of the respondents agreed that it is necessary for the government to introduce policies that would help mitigate the impact of climate change on the environment, but they also consider the requirements of Code Level 6 too stringent and the expectation is too high and that the industry needs more time to adjust, as highlighted by A:

> "*Countries like Germany started looking into sustainable development from the 1970s, which is what the UK government has been trying to do only in the last 5 years*".

All the respondents apart from C believed the 2016 target is too ambitious. Respondent A further pointed out that stakeholders have to change their mind-sets to accommodate alternative methods of construction. Respondents B and G believed that, although technically this date is feasible, the current economic climate will pose a great challenge, thereby making 2016 a farfetched reality. Respondent D thought the blame lay on "technology not being able to keep pace with the demand", and suggested the need for further investment to accommodate the growing demand for the available technology.

3.3 Meeting of Code Level 6 Standards

According to respondent G, meeting the Code Level 6 requirements needs to begin from design stage. This includes taking into account orientation of the building, achieving of energy levels within a competitive budget, maximizing on day lighting and determining the transportation of the excess materials. But it is usually not the case as demonstrated in the two pilot schemes.

All the respondents agreed that the most efficient way of meeting Code Level 6 standards is through the careful consideration of the individual requirements and available technologies. Respondent D further pointed out that it is best to avoid the untested new technologies, which may be unreliable and would just complicate matters on any building site and hamper the achievement of the CSH Standards.

Respondent G perceived water usage to be the most difficult to achieve, due to lack of knowledge by end users. Home owners need to ensure a certain amount of water is used per person per day to meet the requirements, which may be beyond of the control of the construction project team. Respondent G viewed that surface water run-off is another category difficult to achieve because it is dependent on the site ground conditions which the stakeholders have no control over. Poor site conditions and the construction activities on site require robust mitigating measures to reduce surface water run-off. Both respondents A and B agreed that management is the most challenging due to the amount of paperwork required to record material deliveries, workforce mileage, Considerate Constructor Scheme etc. It requires not only the main contractors' contribution but subcontractors' too, as respondent B pointed out:

> *"All people need to buy into the requirements for it to be achieved".*

3.4 Problems encountered

As mentioned earlier, the two projects were initially designed to only achieve Code Level 4, and the upgrading to Code Level 6 caused problems due to design variation and cost increase. To iron out the potential conflicts within the team and get everyone on-board, respondent G suggested that:

> *"The design should be put together through the consultation of all team members and not just through the aspiration of either the Architect or Client."*

Workmanship was identified as a problem in terms of achieving Code Level 6 standard by both contractor respondents H and D. Respondent D exemplified this with the fact that his first Code Level 6 house failed the air test due to flaws in the building process. Lessons learnt were applied in his second house through better workmanship, which significantly improved the quality of the finished product.

The construction industry's culture is another barrier to the effective implementation of Code Level 6 standard, according to respondents A and H. They claimed that most people within the social housing sector as well as the wider industry are resistant to changes and their excuse is "*We've always done things this way, why change now*"? Respondent H contended that the culture in the construction industry has caused BRE to maintain the use of bricks and mortar as opposed to the more sustainable material such as timber because BRE fear the controversy or even uproar any recommendations leaning towards the use of timber might cause.

Another fundamental problem faced by contractors, as pointed out by respondent G, was that many materials are not locally available. In the Northampton project, the timber oak frames used, although a more sustainable choice, could not be sourced locally, but to be imported from Europe. The transportation of the materials not only had cost implications, but contributed to CO_2 emission. The leading time also had an impact on the programme.

3.5 Low carbon technologies

The respondents pointed out there are very limited low carbon technologies available on the market. The most commonly used ones are Photovoltaic (PV) panels, heat exchange units, and grey water harvesting, which are still very expensive as there are only a few suppliers specialising in them. Most suppliers are not keen in supplying materials related to new technologies due to inadequate knowledge and additional costs involved.

Respondent D mentioned the problems when installing PV panels. Despite having followed the specification of "one connection pipe in on a slow bend and one out" in installation, it was apparent that actually two feeds were needed. Though a minor setback, respondent D felt frustrated and it had an impact on the programme. However, on his next housing unit, the PV panels were installed very efficiently due to the lessons learned from the previous house.

Respondent B reported that it took long to choose the most suitable wind turbine in his project due to lack of adequate knowledge and understanding of the new technology. To solve the problem, respondent G suggested that specialist subcontractors installing low carbon technologies should be involved from design stage so they can bring onto the table their knowledge and understanding, which in turn will ensure that these technologies can be incorporated into the project more effectively.

3.6 Promoting Code Level 6

The demand for sustainable homes is still weak on the market due to the current economic recession and lack of knowledge and awareness of Code Level 6. All the respondents were quite enthusiastic about the government's introduction of Code Level 6 in the social housing sector. They were willing to promote Code Level 6 as one of the measures to encourage other stakeholders in the sector towards sustainable development. They agreed that the best way of promoting Code Level 6 is by government introducing incentives such as grants and tax rebates. Besides the "carrots", respondent H strongly believed that the most feasible way of achieving Code Level 6 is through building regulations which leaves stakeholders with no option but to comply.

Respondent A thought seminars that involve manufacturers, suppliers, clients and contractors can update stakeholders on any changes affecting Part L of the building regulations. Respondents C, D and G believed that Code Level 6 can be best promoted through homes that have been built to its standards because through monitoring the energy bills future clients and customers can see themselves how energy efficient these homes can be so that they can be confident that in long term they will be able to recoup the initial investment through reduced energy bills.

4. Discussion

Although not necessarily representative, the fact that these two pilot schemes were only upgraded from Code Level 4 to Level 6 after the projects had already started indicates that there is a lack of urgency and willingness within the social housing sector as well as the wider industry to implement the higher level of CSH. This may be because as Code Level 6 is becoming mandatory only from 2016, people might think there is still time. Moreover, homes with Code Level 6 are undoubtedly more expensive, and in the current global economic recession, clients are understandably very cautious of their investment, especially in social housing sector where the clients are not the end users and may not eventually benefit financially from the more sustainable homes. But not incorporating the Code Level 6 from the beginning of the pilot schemes disregards the whole intention of the CSH, which is the minimum standards to guide house builders how best to design and construction homes sustainably (STuDs, 2010). This has a negative impact on the implementation because key factors such as building orientation, inappropriate site conditions, ecological aspects of the site etc. cannot be fully considered, resulting in design variations, change of materials and ultimately unnecessary cost increase. As Code Level 6 assessments are carried out at both design and post construction stages, it is fundamental to incorporate their requirements into the design (Al-Hassan, 2008). Without it, Code Level 6 simply cannot be achieved. A culture change is needed within the industry so that everyone wholeheartedly embraces the idea of sustainable development. Clients should take the lead in Code Level 6 schemes because they are the main funder of the projects and make most of the key decisions, but every stakeholder should get on board from the very beginning so that the full benefits of sustainable development can be effectively achieved.

The research result shows that the knowledge and experience of CSH is of great benefit on site as it will allow the practitioners to be more appreciative of the principle of sustainable development and therefore be more willing and able to contribute. Experience gained from building lower levels of CSH can prepare the practitioners for the forthcoming mandatory Code Level 6 standard as both the managerial staff and operatives need to be exposed to the new construction methods and sustainable technologies. Lessons learned are transferable as demonstrated in respondent D’s examples. It is quite worrying that both planning officers do not have much knowledge about Code Level 6. Therefore, better promotion and training of Code Level 6 is urgently needed among all the stakeholders.

It is evident from this research that the current definition of a “zero carbon home” is basically not achievable in the social housing sector as the requirements are too stringent. The government needs to consider some of the alternative definitions such as “carbon neutral” to make the Code Level 6 more practical and achievable. Otherwise, the 2016 target will become a mission impossible. The new low carbon technologies are also of some concern because there are only very limited proven technologies available on the market and they are very expensive due to lack of competition. The installation of these technologies requires a new form of competency and knowledge which is lacking among contractors (Williams and Dair, 2006). To make matters worse the integration of these technologies can at times be unreliable (Osmani, and O'Reilly, 2009). Therefore, reliable yet affordable low carbon technologies need to be developed to keep pace with the increasing demand for sustainable homes.

The categories identified as the most difficult to meet are water, surface water run-off and management, all of which have elements beyond the control of the project team. While Code Level 6 has a definite requirement on water usage, CSH has only a minimum standard at entrance level for surface water run-off at entry level and no minimum standard for management. Such flexibility allows the project team to trade-off between categories and achieve the required credits more efficiently according to the specific conditions of each project. But the sustainable materials such as timber unavailable locally is problematic as it means either less sustainable materials will be used or the carbon foot print will be increased by importing them abroad. More research and investment from both the government and private sector is urgently needed in this area.

5. Conclusion

With the ever growing concern of the impact of climate change on the environment, the UK government has introduced CSH to guide house builders to design and construct houses sustainably. The highest of the ratings within the CSH is Level 6 which the government is seeking to become mandatory from 2016. Based on extensive literature review, this research investigated the barriers in the implementation of CSH Level 6 through the experience and opinions of practitioners involved in two pilot social housing schemes in the Midlands.

The research found that a culture change is needed in the social housing sector so that all the stakeholders will have the necessary knowledge and experience to appreciate and embrace the principle of sustainable development and implement it in practice. Although the requirements of Code Level 6 seems stringent, a level of flexibility exists and it is possible to achieve the required credits through careful trade-off between different categories and through available technologies, but this has to start from the very beginning of a project and get everybody on board as soon as possible, otherwise it would be very costly. It recognised that the definition of a "Zero carbon home", which is key to the achievement of Code Level 6, needs to be amended. The availability of locally sourced materials poses a challenge for contractors so investment is needed to supply such materials on a large scale in the future.

To promote Code Level 6, the government should introduce incentives such as grants, discounts on low carbon technologies, stamp duty exemption for greener homes and give tax breaks for energy efficient homes to stimulate such demand. Building regulations should be amended regularly to reflect the development of technology and environmental requirements. Monitoring the performance of completed homes built to Code Level 6 and providing the feedback to future clients and end users can also effectively promote the sustainable homes.

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The life and death of a sustainable housing concept? The trajectory of passive houses in Denmark as part of the zero carbon transition

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Abstract

This paper makes an exploratory analysis of the diffusion of passive houses in Denmark using transition theory. Strategic niche management and technological innovation system approaches are combined to provide a framework that allows for multiple dynamics i.e. social forces enabling or constraining changes, especially niche developments and the role of legitimacy. The passive house niche analysis shows a slow process, barriers of cost and technology and limited adoption in Denmark; roughly 18 projects over the last six years, and a slow descent over 2011-2012. The concept has early moral legitimacy, but the further development of legitimacy fails as costs and indoor climate makes the cognitive legitimacy contested. The passive house concept competes with other sustainable building niches, they are all small and they appear to have been introduced successively over time. Finally there are a tendency of segmentation of villas, small buildings and office buildings respectively. Sustainable building exhibits a particularly active role for government policymaking, or in transition theory terms "regime internal" dynamics. These combined dynamics between sustainable housing niches, the regime internal dynamic and globalisation as well as EU-regulation are counter to transition theory assumptions dominated by the EU- initiatives. The analysis moreover leads to the view that sustainable housing concepts are only viable in time windows, and that the contribution of the passive house trajectory was a stepping stone towards low carbon housing.

Keywords: passive houses, transition theory, Denmark, sustainable building

1. Introduction

Many change initiatives and conceptualisations in construction management research and practice tend to build on relatively insular initiatives (Green, 2011). The understanding of sector change within construction remains under conceptualised. Especially there is a need to address the intersection between innovative and conservative forces as well as the type of drivers around these change processes. The reputation of the construction sector as conventional and lacking of innovative forces is often alluded to but efforts are seldom put into trying to explain or analyse the barriers to change. With this as our point of departure this paper investigates the introduction of Passive houses onto the Danish market. Passive houses have been established as a sustainable housing concept in central Europe for quite some time and a number of houses and building projects have been constructed following the given criteria. However in a Danish context the diffusion has been slow

By adopting a theoretical framework combining strategic niche management research (SNM) and Technological Innovation Systems (TIS) this paper presents an analysis of the emerging innovation system of sustainable buildings in the Danish Construction industry. It places passive houses as one among several competing concepts and niches. In this perspective sustainable buildings are part of a multifaceted landscape of innovation around an existing regime, built on the current ways of working and developed over generations. The housing/building regime is challenged from various niches and from the socio-technical landscape through trends such as globalization and EU- initiatives. The passive house niche is here subjected to an analysis showing the processes, experienced barriers and limited adoption. This is juxtaposed with other sustainable building niches and their competition is mapped and discussed. The paper further discusses the role of government policymaking as a 'regime internal' dynamic. Combining these dynamics, i.e. social forces enabling or constraining changes between sustainable housing niches, the regime internal dynamic and globalisation as well as EU-regulation leads to the view that sustainable housing concepts are only viable in relatively short windows of time; and that the contribution of passive house trajectory is more of a stepping stone towards low carbon housing, than a final solution.

2. Method

The paper adopts an interpretive sociology framework. The theoretical position combines two transition theory contributions, that of Science Technology and Society studies and Evolutionary Economics in accordance with Coenen and Lopez (2010) and Markard and Truffer (2008).

Given the explorative nature of our research the empirical design is a case study of the development of passive house in Denmark. The study uses a mixed method approach combining quantitative and qualitative data collected through several sources. This includes mapping of sustainable housing concepts and their emergence through desk research using Google and Infomedia (Danish Newspaper database) and other press articles. Further secondary data have been retrieved from students work such as master theses supervised by the authors. First hand data collection includes participation in architects and engineers' workshops on the topic. The trustworthiness of results is achieved through triangulation, by the comparison of information collected through different channels (Bryman and Bell, 2007).

It is recognised as a limitation of the paper that the full implication of combing of strategic niche management and technological innovation systems is not discussed here.

3. Theoretical framework: Transition theory

The transition theory literature is currently being developed as a response to the societal challenges of climate change. It encompasses looking at the drivers, emerging actor constellations, technologies and barriers in play. The two transition theories selected here, Strategic Niche Management (SNM) and the Technological Innovation System (TIS), both offer conceptualisations of sectorial change affected by multiple dynamics. Here the combination of the two is chosen to complement and strengthen their respective conceptualisation of sectorial dynamics. In brief the multilevel framework and strategic niche management of Geels and others (e.g. Geels, 2005, 2011; Schot and Geels, 2008) focuses on the analysis of dynamics of upcoming niches challenging the existing regime, whereas the technological innovation system (e.g. Bergek and Jacobsson, 2007) offers a broader set of potential dynamics including the role of the public audience, i.e. legitimization. Bergek and Jacobsson (2007:576) define legitimation as “acquiring a social acceptance of new technologies”.

3.1 Multilevel framework and strategic niche management

The SNM view approaches innovation in a sector as a socio-technical phenomenon. Three levels of socio-technical interaction are identified: Niches form the micro-level where innovations emerge; The socio-technical regime forms the meso-level, which accounts for the dominating stabilized socio-technical pattern of interaction that are reproduced by institutionalised learning processes; and Finally the macro-level which is shaped by the socio-technical landscape, an exogenous environment beyond the direct influence of niche and regime actors (Geels, 2005).

Schot and Geels (2008:545) note:

“The core notion of the multi-level perspective (MLP) is that transitions come about through interactions between processes at different levels: (a) niche innovations build up internal momentum; (b) changes at the landscape level create pressure on the regime; (c) destabilisation of the regime creates windows of opportunity for niche innovations”.

This suggestion that regime shifts would (predominantly) come about through bottom–up processes of niche expansion is addressed in this contribution. Within sustainable buildings, regime push is an important dynamic. This means that Schot and Geels’ (2008) argument regarding that alignments of processes at multiple levels are explanatory for construction Niche innovations are still important, but these innovations would probably diffuse more widely if they link up with ongoing processes at regime and landscape levels. The strategic niche management perspective allows for a range of actors to be included in the conceptualisation. At the niche level entrepreneurs as single persons would occur, whilst at the regime and landscape level aggregate actors like the EU and nation states would occur. It should be noted that the strategic niche management perspective does not encompass processes of legitimation. As such it does not give a central role to the public audience, processes of public communication and other elements of legitimation processes. Even if such social processes are not counter or alien to the dynamics outlined.

3.2 Technological Innovation systems

The technological innovation system (TIS) approach focuses on the dynamics of the systems both in terms of structural growth and key innovation-related processes. Carlsson and Stankiewicz (1991:93) define a technological system as:

“a dynamic network of agents interacting in a specific economic/industrial area under a specific institutional infrastructure and involved in the generation, diffusion, and utilization of technology.”

According to Bergek et al. (2008) a TIS is made up of: (i) firms and other organisations; (ii) networks; and (iii) institutions. Firms refer to firms within the entire value chain and organisations include universities, research institutions, industry- and other professional organisations. TIS as championed by amongst others (Bergek et al., 2008; Carlsson and Stankiewicz, 1991; Jacobsson and Bergek, 2011) views the ‘functions’ of the innovation system as central. The eight key functions are:

- Development of formal knowledge
- Entrepreneurial experimentation
- Materialisation
- Influence on the direction of search
- Market formation
- Resource mobilisation
- Legitimation
- Development of positive externalities

The interplay between these functions is multiple, complex and cannot be reduced to a linear progression. *Formal knowledge* according to the TIS approach (Bergek et al., 2008) is an explicit research-based knowledge. The TIS develops if it manages to expand the breadth and depth of its knowledge base and diffuse and combine it into the system. *Entrepreneurial experimentation* on the other hand is development of tacit, explorative, and applied knowledge. Experimentation is viewed as important for the innovation system, through the innovators conducting technical experiments, struggling with uncertain applications and markets and discovering and creating business opportunities (Bergek et al., 2008). *Materialisation* involves the development of (and investment in) artefacts such as products, production plants and physical infrastructure within the technological innovation system. The *influence on the direction of* search is one of the more agency oriented elements in the TIS model. In the early interaction some actors are able to orchestrate the assembled effort and direct it in a particular direction and thereby strengthening the TIS development. Such a dynamic of directed search would also attract new external actors, for example supply-side actors that direct their search and investments towards the TIS. It could also attract customer oriented actors who find the direction attractive and representing future feasible products. *Market formation* relates to articulation of demand and market development in terms of demonstration projects, nursing or niche markets (Schot and Geels, 2008), bridging markets and, eventually, larger markets and large-scale diffusion. *Resource mobilisation* is about the TIS having to mobilize human capital, financial capital and complementary assets. When the mobilisation goes further than suppliers and users to other sources it is a sign of a high mobilisation. The socio-political process of *legitimacy* forms through actions by various organisations and individuals. Central features are the formation of expectations and visions as well as regulative alignment, including issues such as market regulations, tax policies or the direction of science and technology policy. *Development of positive externalities* reflects the strength of the collective dimension of the innovation and diffusion process. It also indicates the dynamics of the system since externalities magnify the strength of the other functions. It should be noted that other contributors have argued that functions can be substituted with activities in appreciating a more agency oriented conceptualisation of an innovation system (e.g. Markard and Truffer, 2008).

3.3 Synthesis of MLP/SNM and TIS

Both models implicitly and explicitly operate with different levels of aggregation. Geels (2011) claims that these levels can be derived to concrete contexts. Markard and Truffer (2008) suggest that a technological innovation system and the niche/regime level are at the same aggregation. At the niche/regime level at least five of the so called functions in TIS, innovation processes overlap heavily with the niche dynamics described in Schot and Geels (2008):

- Entrepreneurial experimentation
- Materialisation
- Influence on the direction of search
- Market formation
- Resource mobilisation

The *entrepreneurial experiment* and influence on the direction of search are very close to the ‘competition of design’ and ‘search for a dominant design’, conceptualised by Geels. These concepts highlight how an early development of a concept/technology, in this case a sustainable building concept, would develop under protective conditions amongst designers and users with market mechanisms relaxed. The *market formation* is a gradual process from a tight network of producers and users into slightly more decoupled network relations with commencing demand and supply mechanisms. The two aspects of ‘legitimisation’ and ‘creation of positive externalities’ are on the other hand not an immediate commonality between the concepts. *Legitimacy* is related to obtaining social acceptance and compliance with relevant institutions. Legitimacy is not given but has to be formed through conscious actions by various organisations and individuals in a socio-political process. Gaining legitimacy would involve cognitive, normative as well as regulative aspects. The most commonly described strategy for industry legitimation is to conform to established institutions. However, deinstitutionalisation and reinstutionalisation, as described by Greenwood et al. (2002), is another means of attaining it. If legitimacy is attained for a technological innovation this would support obtaining resources for its further development, and it would generate demand and give actors in the new TIS political strength. For example, Bergek and Jacobsson (2008) argue that attaining legitimacy is a prerequisite if new industries are to be formed around renewable technologies, as the incumbent energy production regimes might otherwise actively counter them. Greenwood et al. (2002) point at several steps in gaining legitimacy. They assign early legitimacy as being value oriented 'moral' legitimacy. If the emerging products and practices cannot be referred to existing institutions, functional superiority has to be established, labelled 'pragmatic' legitimacy. At a later stage the legitimation might solidify and become cognitive (Greenwood et al., 2002)

4. Case: Passive Houses in Denmark

A passive house according to the Darmstadt criteria (Passivhaus Institute, 2012) encompasses four central properties: (i) The specific space heating demand should be lower or equal to 15 kWh per m2 per year; (ii) the heating load should be ≤ 10 W/m; (iii) the tightness of the building envelope should be ttested with a pressure test showing air changes of ≤ 0.6/h; (iv) the specific cooling demand should be ≤ 15 kWh per m2 per year and the total specific primary energy demand ≤ 120 kWh per m² per year.

4.1 The central European development

The early development towards passive houses can be traced back to work on experimental low energy houses that was undertaken simultaneously in a number of countries, e.g. Austria, US, Sweden, Denmark, Germany, during the period 1975-1990. From the early 1990's the development around Institut Wohnen und Umwelt, Darmstadt, took precedence. The first batch of houses built according to Darmstadt standards, such as those in Dörpe and Kranichstein (Hinz, 1994), were used to develop and institutionalize a standard for passive houses, incorporating specific design parameters, energy consumption calculation software (PHPP) and tests. By the year 2000 around 100 passive houses had been built according with the Darmstadt standards (passivhausinstitute.de, 2012), with a well-established design. The Darmstadt institute database portfolio of passive houses as of early 2012 encompasses 1753 projects. 1586 of these are in Germany, 33 in Austria, 12 in Denmark, 10 in Switzerland and 3 in Sweden. The vast majority of these projects are single family houses.

4.2 The context of Danish building

Following the oil crises in 1974 the Danish building sector began to pursue a coordinated path of improving insulation and reducing the energy consumption (Marsh et al., 2010). According to these authors the Danish population grew with 7% reaching 5.4 million in the period 1975- 2005 while in the same period the total floor area of housing grew with 53%. Average housing space per capita grew from 34 m2 to 48 m2. The housing stock in 2005 was at 2.6 million units, encompassing 1.5 million singular units (houses). In the period 1975- 2000 (after the oil crises) a 19 percent reduction of heat consumption was realized, an improvement that was mitigated by a 69 percent growth in energy consumption due to more intensive use of household appliances and IT (Marsh et al., 2010). Marsh describes this period as a long-term political and social consensus that developed in response to the 1970s oil crisis. A range of planning, fiscal, and regulatory policy initiatives were taken. As a result energy planning in Denmark underwent a radical change from oil to natural gas and district heating, produced by centralized combined heat and power plants (Marsh et al., 2010). It can be added that it is only by around 2002 that EU initiatives began to have importance since Danish regulation and other initiatives up to that point were ahead of those stipulated by the EU. The building volume in 2007 to 2011 is shown below. By including 2007 the impact of the financial crisis in 2008 becomes clearer.

	2007	2008	2009	2010	2011
Commenced new build in mio m2	10,6	9,15	6,30	5,15	4,75
Commenced Housing Buildings	26000	17000	10000	10500	11500

Figure 1: Building activity 2007-2011 (source: Denmark Statistics)

New building regulations have been implemented in Denmark over the last ten years. These have largely followed EU directives and have substantially tightened the demands on energy consumption. In 2006 building regulations were implemented following the EU directive EUBP 2002. Introducing two energy classes 1 and 2 (also called 2015 and 2010) referring to the years they would become obligatory. The building regulation BR10, from august 2011 installs a third class '2020' with even stricter demands. These reforms have been accompanied by a range of initiatives such as Directive No 2010/31/EU on the energy performance of buildings, the EU (2009) directive leading to national renewable energy plans, initiatives of developing sustainable skills amongst construction workforce, financial and fiscal arrangements.

In summary, the development can be divided into two phases. In the first phase between1974-2002, Denmark as a national state had a broad alliance of actors pushing for energy savings and accompanying technologies; whereas from 2002 and onwards the initiative shifted to the EU. The reform tempo has been quicker over the past ten years than previously. The Danish housing sector, like in many other countries, had a serious bubble that burst in 2008.

4.1 The story of passive houses in Denmark

The interest for passive houses occurs in the above sketched context of sustainable housing and more traditional housing development. As described by Marsh et al. (2010) there has been a strong tendency in Danish building to gather around one common solution, which is then supported by law with occasional subsidies. This tendency has continued even after the EU taking over the initiative, but now with implementation of EU legislation as the key driver. The passive house community is therefore a niche environment that distinguishes itself from other parts of the industry. Especially the architectural environment in Denmark second largest city, Aarhus, has been important in constituting this niche. The architect school in Aarhus, local architects and alliances of architects, consulting engineers and contractors have followed the German development over a long period of time. This community shares features with other grassroot developments of renewable energy, such as wind turbines (Steen et al. in Foxon et al. (2008)). In 2005 the consultancy Ellehauge and Kildemoes obtained funding for the EU-project "Promotion of European Passive Houses" together with a range of European partners. The clear understanding of the project is that passive houses are a well-documented sustainable solution. Ellehauge and Kildemoes created a website, commenced educational activities, and arranged study visits to Germany and Austria, together with other knowledge dissemination activities. The project was finalized in 2007, but the website was continued and later transferred to another social carrier, a new association for passive houses in Denmark. One active person in this niche community, the architect Olav Langenkamp, designed and built his own villa according to passive house criteria and got it certified. The house was completed in March 2008 and is the first passive house in Denmark. When building the house Langenkamp had to use German suppliers to get components that would be certifiable. The contractor was therefore a German company, Ökologischer Holzbau Sellstedt (Langenkamp.dk, Passivhus.dk).

ISOVER, the insulation manufacturer initiated a project of 10 passive houses "komforthusene", where the idea was to let building sector actors tender for the various houses to obtain as much experience with passive houses as possible (cf. the breath of formal and informal knowledge (Bergek et. al. (2008)). Also, part of the project was that the experiences with indoor climate and more should be documented, involving Aalborg University in a three year long measurement program. By September 2008 eight out of the ten planned passive houses, Komforthusene were inaugurated by the Minister of climate. Two of the "Komforthusene" houses were later changed into non-passive houses. Through these early projects the passive houses got the reputation of being expensive. In a later evaluation report (Isover, 2010) it is shown that the Komfort houses are indeed more expensive to build. Isover (2010) claim 6-12 %, but also claim that compared to longer term energy savings these extra expenses are compensated for within fifteen years. Apart from being expensive the early passive houses all share the dependence on German suppliers of components. This also goes for the 2009 dormitory project "H2 College" (Bertelsen and Koch, 2011). The dormitory encompasses 66 apartments, in two blocks built as passive houses, with hydrogen and earth warming. A building association Fruehöjgaard is the client and Aarhus Arkitekterne, NIRAS, and Ökologischer Holzbau Sellstedt were the architects, consulting engineers and contractor respectively. Gradually over 2009-2010 various component suppliers start engaging in passive house projects. In 2010 for example the Danish window manufacturer Rational was part of a vocational training school, built as a passive house, using Rationel Aldus Super Lavenergi windows.

In summary, the development of passive houses mobilized both small grassroot players as well as larger players in the industry. The single house projects become "mature" and its concepts market like where the clients enter a more classical relation when demanding a project. But most of the Danish passive house projects occur as part of publically financed demonstration and/or innovation projects with the intention of first communicating the values and qualities of passive houses to a wider audience of possible future clients (what Greenwood et al. (2002) would call moral legitimacy); second to underpin this by supporting the legitimization process in the form of providing formalized knowledge about the design, the costs, the building process etc. A less controllable part of the communication is that the passive houses appear expensive and difficult to live in as the indoor climate is controlled with complex equipment.

4.2 The concepts competing with passive houses

From 2005 and onwards an increasing number of sustainable housing concepts have emerged. In particular, the preparation activities before the United Nations Climate Summit, COP 15 in 2009 seems to have initiated a number of projects attempting to exploit the marketing options related to the summit. Figure 2 provides a list of concepts found in Denmark.

Concept/Year of introduction in DK	Found/Estimated number of projects	Actors (examples)	Examples
Passive house, Darmstadt criteria/ 2008	18		H2 College (dormitory) Komforthusene
Active House (Velux group)/2009	3	Velux	Lystrup, Cph.
DGNB (Deutsche Gesellschaft für Nachhaltiges Bauen)/2012	2	Green Building Council Danmark Ramboll Ålborg University	
Svanemærket (Nordic Ecolabel)/ 2011	2	Odense Kommune, pluskontoret, Køge kommune, Det grønne hus (Agenda 21)	2 kindergartens Fremtidens Parcelhuse Køge
BREEAM (Building Research Establishment Environmental Assessment Method)/2010	>6 large Projects	Grontmij DK	Vestas HQ, Sillebroen shopping center, Grontmij HQ
LEED (Leadership in Energy and Environmental Design)/2010	>7 larger projects	COWI,KPC, Sjælsø	FN-byen, UL Intern. Demko HQ
EU Green House/2008	7	NCC	Skejby Company House I-III (also BREEAM)
Energy Class II (EUBD 2002)/ 2010	>4 large projects		KPMG, Flintholm City Court Kolding Christian Union HQ Industriens Hus,
Energy Class I (EUBD 2002)/2006	>9 large and small projects and7 under construction	Arkitema, KAB, Ramboll, Pihl, Lind og Risør, a.m.o	Stenløse Syd Multimediehus Navitas
Other concepts made once Sabro, ZERO+, lavenergi,	5		Sabroe Sønderborg Zero plus Vordingborg

Figure 2: Sustainable Building concepts 2005-2012 (source: desk research)

The year of introduction, as provided the left hand column, is given as when the first realised building occurs. The list is not exhaustive but gives an impression of a veritable cacophony of concepts and indicates a limited breakthrough of sustainable building concepts compared to the overall building activity in the same period.

5. Discussion

The passive house niche analysis shows slow and hesitant processes, involving public support as the lever for development. It took 16 years from the first realised passive house outside Darmstadt in 1994, to realise the 18 Danish projects in our sample. Indeed, all were built after 2006. As the niche commenced to produce material results a key experienced barrier turned out to be the initial price of the houses. As a direct result the passive house concept has experienced limited adoption, keeping it on the niche level. This is despite of its German origin and backup, which provides well established knowledge, legitimate institutions, design procedures and more. Over 2011 and 2012 we found three finalised passive house buildings, compared to six in each of the years 2009 and 2010. When the passive house development is juxtaposed with other sustainable building niches and their competition is mapped it becomes clear how voluntary concepts that go beyond what is specified in the legislation have been introduced in succession over time, e.g. passive, active, DGNB. But it is also clear that the early compliance with future legislation, especially energy class 1, has tended to dominate these voluntary steps. There are tendencies of segmentation, where LEED, BREEAM, DGNB a.o. are used for office buildings, whereas passive house, active house, Svanemærket and ZERO+ mostly are used for single family houses and smaller buildings such as kindergartens.

Both TIS and SNM highlight the importance of a dominant design. This study of sustainable building shows that none of the concepts has obtained this. Instead they continue to exist in parallel. Passive houses represent a well stabilised design with an institutional set up in Germany. Nevertheless this does not render the concept sufficiently strong as concept in what is a growing and active part of the construction market. We have seen how the EU processes create regime dynamics that are more prevalent for the development of sustainable buildings than the niches. Usually it is expected that regime driven innovation would conserve existing ways of working (Geels, 2005; Markard and Truffer, 2008). This is evidenced by the far bigger number of projects built according to the required levels set out in the official regulations during the investigated period. In the Danish setting the restructuring of government responsibilities into a ministry of climate, energy and building can even be viewed as the more important dynamics in 2011 in the sustainable building context apart from the central EU initiatives discussed above. Seen from a grass root perspective the commodification of a type of house, using a certificate is less interesting than promoting sustainable buildings in a broader sense. There will therefore be a tendency for grassroot engagement to move from one innovative approach to the next, especially if the approaches get too commercial. In terms of legitimation it appears that passive houses had a certain degree of moral legitimacy in the 1990’s and that this contributed to the creation of the first houses. However as the passive house concept was well developed it could also be argued that it also possessed a certain degree of cognitive legitimacy in these early stages. At a later stage the cognitive legitimation was more difficult to retain as active house were perceived as a stronger concept (it gained pragmatic legitimacy, i.e. it was not yet underpinned by formal knowledge) and the passive houses suffer from contested reputation because of higher cost and indoor climate issues.

6. Conclusion

The passive house niche analysis showed a slow process, barriers of cost and technology, limited adoption and over 2011 and 2012 an apparent descent. Roughly 18 projects over the last six years have been realised. The niche has not been able to exploit its basis in formalised knowledge and cognitive legitimisation to become a dominant design. When juxtaposed with other sustainable building niches, it appears that all these are small and they appear to substitute each other over time. Also there are a segmentation of villas, small buildings and office buildings respectively. Rather than just being about niche technologies it is the voluntary early adoption of future law that is prevalent. Therefore government policymaking as the “regime internal” dynamic contributes as well. Compliant with the theoretical framework there are multiple dynamics in play. These combined dynamics between sustainable housing niches, the regime internal dynamic and globalisation as well as EU-regulation leads to the conclusion that sustainable housing concepts are only viable in fairly confined windows of time, and that the contribution of passive house trajectory probably is more of a stepping stone towards low carbon housing, than a final solution.

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A Multi-Objective Optimization Model for Sustainable Building Design Using Genetic Algorithm and Fuzzy Set Theory

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Abstract

Building facilities which provide shelters and facilitate various anthropogenic activities consume approximately 40% of the total energy in the world and are responsible for one third of global greenhouse gas emissions. Therefore, enhancing energy efficiency of buildings is one of the most pragmatic and effective measures for sustainable development in the building sector. As different configurations of building elements could affect the energy performance of buildings significantly, the early conceptual design stage is of paramount importance to the success of energy and carbon emissions reduction in buildings. In this paper, a multi-objective model is developed for the optimization of building design, with a special focus on the building envelope and indoor thermal environment settings. Genetic algorithm (GA) is applied as the optimization engine based on three design objectives, namely the economic aspect, energy performance and comfort of the end-users. The economic aspect of a design solution is appraised according to the life cycle costing, which discounts the costs incurred throughout the building life cycle into a present value and thus provides a common ground for comparison. As for the energy performance, a widely-adopted building energy simulation program, namely EnergyPlus is used for evaluating the energy consumption of a design solution. Through the fuzzy set theory, the uncertainty and vagueness regarding the end-users' perception on comfort judgment towards the indoor thermal environment is captured and quantified. At the end, illustration of the model is presented via a case study to optimize fenestration configurations and indoor temperature setting of a small office building.

Keywords: Building design, energy efficiency, multi-objective optimization, genetic algorithm, fuzzy set theory

1. Introduction

Buildings not only provide dwellings and venues for various types of anthropogenic activities but also deliver services to fulfill various end-users' requirements, and these have resulted in a significant proportion of energy consumption. According to USEIA (2010), the building sector consumes approximately 40% of total energy and releases 33% of carbon emissions globally. Therefore, sustainable concepts should be built into the building design so as to help achieve the goal of energy conservation and carbon emissions reduction. Nonetheless, building design is a complicated process which involves a large number of design variables (i.e. building elements). While the overall design solution is developed by taking into account the features and requirements of each design variable, such combinatorial property renders the design space too large for an exhaustive exploration. In addition, as sustainable building design always involves multiple design objectives which are conflicting and non-commensurate, it is desirable for clients and designers to have a better picture about the trade-off characteristics of different constraints and requirements before deciding the most suitable design solution.

Over the years, many research studies have been conducted to establish an optimal building design. For instance, Al-Homoud (1997) examined how to minimize the annual operational energy utilization when designing office buildings with various scales. Likewise, Coley and Schukat (2002) focused on operational energy consumption for heating and cooling. However, by merely considering the reduction in operational energy consumption can be misleading, and it is necessary to consider the economic aspects as one of the design objectives should we wish to obtain cost-effective solutions (Wang et al, 2005; Wang et al, 2006; Znouda et al, 2007; Diakaki et al, 2008; Shi, 2011). Adding to the list of design consideration is the end-users' comfort which is regarded as a secondary concern currently. However, as the fundamental function of buildings is to serve the end-users, an uncomfortable internal environment could impair the joviality, amenity, productivity and even health of inhabitants. Consequently, end-users' comfort and satisfaction should be an important index gauging the quality of building design.

This paper presents a multi-objective optimization model for sustainable building design by considering three conflicting design objectives, namely: economic aspect, operational energy consumption and end-users' comfort.

2. Methods

2.1 Multi-objective genetic algorithm (MOGA)

MOGA is selected as the optimization algorithm of this study due to the following two reasons: (i) the problem has three incommensurable design objectives and thus it is impossible to come up with a single optimal solution and hence a set of non-dominated Pareto-optimal solutions should be identified instead; and (ii) it is a combinatorial optimization problem with a considerably large design space. MOGA is a specific type of genetic algorithm (GA) – an evolutionary algorithm based on the principle of natural selection – aiming at solving complex optimization problems with multiple and conflicting objectives. Compared with the single objective GA where the fitness of a solution is based on the value of the sole objective function, the fitness assignment method in MOGA is different and should be able to represent the collective effect of multiple objectives. In this paper, one of the most efficient MOGA methods known as the non-dominated sorting genetic algorithm II (NSGA-II) as developed by Deb et al (2002) is adopted. In NSGA-II, the fitness of a solution is based on its non-domination rank in the current generation as well as the "crowding distance", which measures how close a solution is to its neighbors in the objective space. Under the same non-domination rank, solutions with a farther crowding distance are preferable as it implies a less crowded neighborhood and a higher degree of diversity. Deb et al (2002) demonstrated that NSGA-II can perform better in converging towards a near true Pareto-optimal front while preserving diversity among population when compared with two other widely-adopted contemporary MOGA methods.

2.2 Fuzzy set (FS) theory

Human's perception toward comfort is subjective, vague, and uncertain in nature. Therefore, the fuzzy set theory is appropriate for this study to capture such vagueness inherent in comfort perception. Fuzzy set theory has been recognized as an effective method to represent issues without precise boundaries (Zadeh, 1965). As a paradigm shift, the notion of fuzzy set is a generalization to the classical crisp set. In a classical crisp set A, an element x can be either belong or not belong to A, in other words, the membership of x to A can be either 1 or 0. However, in fuzzy set, instead of crisply discriminate members and non-members, an element's membership can be any value within 0 to 1. The definition of fuzzy set is that if X is a collection of objects denoted generically by x, then a fuzzy set $\tilde{A}$ in X is a set of ordered pairs:

$$\tilde{A} = \{(x, \mu_{\tilde{A}}(x) \mid x \in X\}$$

where $\mu_{\tilde{A}}(x)$ is called the membership function or grade of membership taking values from [0,1] and it specifies to what degrees x belongs to $\tilde{A}$. Each fuzzy set is completely and uniquely defined by one particular membership function.

2.3 Building energy simulation program

The interactive relationship among the building elements, internal and external climate conditions, end-users' behavior, and mechanical and electrical systems used in a building can be very complicated and this calls for the use of a computer-aided building energy simulation program to evaluate the energy consumption of a design solution. A popular and sophisticated building energy simulation tool – EnergyPlus is used in this paper. EnergyPlus is a whole building energy simulation program for modeling the energy performance of a building. This tool can accurately estimate the energy consumption according to the description and configuration of the building's physical make-up and associated mechanical and electrical systems (USDOE, 2011). The inputs and outputs of

EnergyPlus are in simple ASCII text format, which means that the interface between the simulation and optimization modules can be easily established using only low-level file input and output functions in a programming package.

3. Model description

3.1 Objective functions

As indicated earlier, three objective functions are considered in the model, namely the cost and the energy consumption (with minimization-purpose) as well as the end-users' comfort (with maximization-purpose).

3.1.1 Cost

Cost is represented by the life cycle cost (LCC) due to its capability to account for the cash flow incurred over the building lifespan. LCC allows discounting the life cycle cash flow of design alternatives back to a present value and thus establish a common ground for direct comparison amongst different alternatives. The underlying concept and principle of LCC is time-value of money, which derives the following generalized formula of LCC:

$$LCC = I + \sum_{i=1}^{N} \frac{E_i + C_i}{(1+d)^i} - \frac{RES}{(1+d)^N}$$

where I is the initial capital investment; N is the lifespan; E_i is the energy cost (tied to local utility rate) in year i; C_i is other miscellaneous cost incurred in year i for operation and maintenance; d is the appropriate discount rate; RES is the residual/scrap value of the building at the end of the lifespan.

3.1.2 Energy consumption

The energy consumption of a building design solution is highly dependent on the configuration of building components. Therefore, the energy consumption value should be based on the simulation results derived from EnergyPlus.

3.1.3 End-users' comfort

To simplify the problem, the indoor air temperature is assumed to be the only variable affecting end-users' comfort at this stage. Therefore, other relevant factors, such as the humidity and ventilation rate, would remain constant for the computation purpose. The objective function of end-users' comfort is simply the membership function defining the fuzzy set "comfortable temperature". Human's perception on the most comfortable temperature has the following two features: (i) with regard to the best temperature it is impossible for different people to agree upon an exactly same single best temperature, and yet the variation is limited to a small range; and (ii) there is a critical temperature smaller than which every rational person would feel “intolerably too cold” and so it is with the “intolerably too hot” temperature.

Assuming that the membership value varies linearly, the membership function would be in trapezoidal shape. An ongoing survey is being carried out among office building end-users in Hong Kong to identify the comfortable temperature range and the two critical temperature points. From the survey results with 21 office white-collars so far, at the current stage, it is temporarily identified that the best temperature range is 22-23 ^{0}C with the two critical temperature points being 18 and 27 ^{0}C as illustrated by Figure 1. The results are comparable to the findings as reported by Weglarz and Narowski (2011) and the variation is mainly attributed to the climate difference between Hong Kong and Poland.

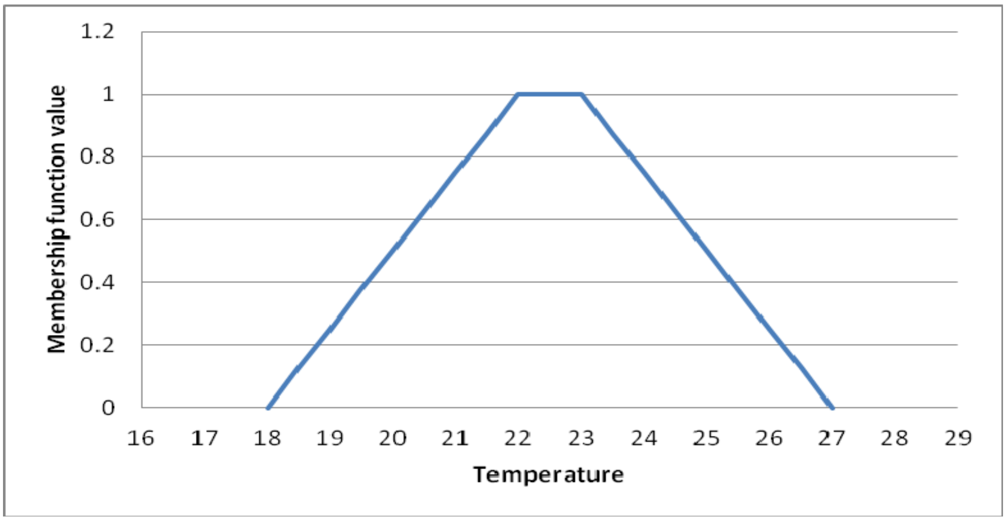

Figure 1. Fuzzy membership function of “Comfortable temperature”

3.2 Implementation framework

The implementation framework is illustrated in Figure 2. Under the MATLAB environment, the solutions of each generation are converted to input files for EnergyPlus simulation and the required results from the output files can then be extracted for the evaluation of objective functions with FS theory and LCC. Subsequently, selection, crossover and mutation are applied to form the new generation. Such iteration would repeat until the stopping criteria are triggered and then the final solutions are obtained.

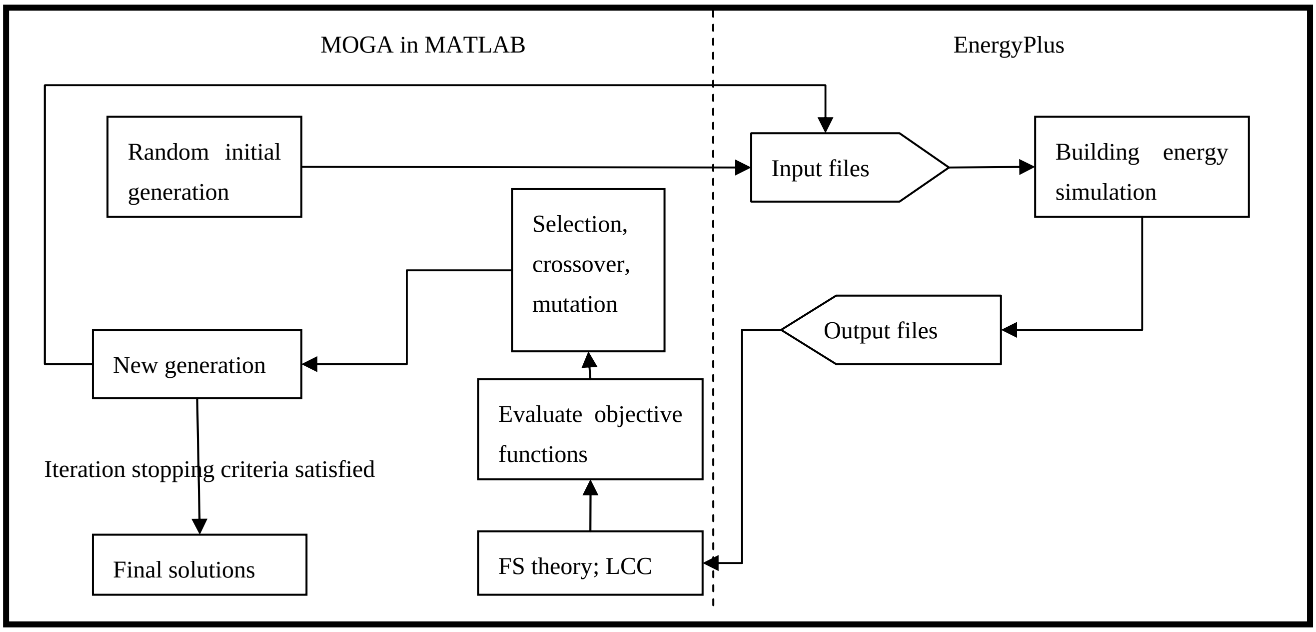

Figure 2. Implementation framework of simulation-based optimization

4. Case study

4.1 Building description

The reference building used in this case study – a hypothetical small office building – is configured based on the U.S. Department of Energy Commercial Reference Building Models and the relevant features of this small office building in detail can be found in Deru et al (2011). Here, a brief summary is provided for quick reference. The building location is assumed to be in Chicago and this determines the EnergyPlus weather file. The building is in rectangular shape with an aspect ratio of 1.5 and azimuth of zero degree, has 1 floor and 1 attic with a floor area of 511 m^2 (Figure 3). The wall areas, window areas and window-to-wall ratios in each orientation are summarized in Table 1. For the internal gains, the building has 28 occupants with lighting and equipment loads both equaling 10.76 W/m^2 (USDOE, 2012).

Table 1. Areas of walls and windows facing north, east, south and west orientation (source: USDOE, 2012)

	Total	*North*	*East*	*South*	*West*
Gross Wall Area [m^2]	*281.51*	*84.45*	*56.3*	*84.45*	*56.3*
Window Opening Area [m^2]	*59.68*	*16.73*	*11.16*	*20.64*	*11.16*
Window-Wall Ratio [%]	*21.2*	*19.81*	*19.81*	*24.44*	*19.81*

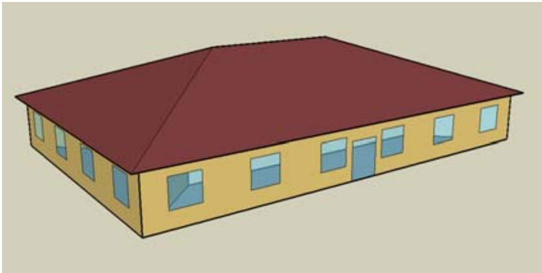

Figure 3. Sketch of the reference office building (source: USDOE, 2012)

Five design variables are considered in this case study, namely (i) cooling temperature set point during summer days, (ii) south wall window type, (iii) north wall window type, (iv) east wall window type, and (v) west wall window type. The cooling temperature ranges from 19 to 28 ^{o}C with a varying step of 1^{o}C. As summarized in Table 2**,** five types of window are available for each wall. The U-value, solar heat gain coefficient and price for each wall type are obtained from Hamdy et al (2011). As a result, there are totally 6,250 (i.e. $10x5^4$) potential design solutions.

Table 2. Detail of different types of window (source: Hamdy et al, 2011)

Window type #	*U-value (W/m2 K)*	*Solar Heat Gain Coefficient*	*Price (HK$/m2)*
1	*1.4*	*0.57*	*2212*
2	*1.1*	*0.57*	*2273*
3	*1*	*0.46*	*2519*
4	*0.85*	*0.42*	*2949*
5	*1.1*	*0.38*	*2580*

4.2 Parameters

Parameters for computing life cycle cost are: lifespan of windows is 10 years; discount rate is 6%; and end-of-life residual value for windows is zero. Parameters for MOGA are: maximum number of generation is 50; number of chromosomes in one generation is 20; selection method is tournament selection with tournament size of 2; crossover method is single point crossover; mutation rate is 0.02.

4.3 Results and discussion

The results are plotted on a plane with LCC being and annual operational energy consumption being the x-axis and y-axis respectively. Different comfort membership values are signified by different marker shapes and colors. With 50 generations and 20 solutions per generation, a total of 1,000 design solutions have been evaluated. Figure 4 shows the Pareto-optimal solutions from all the solutions evaluated with the five separate clusters of dataset representing different comfort membership values. It also exhibits the compensation pattern between the comfort level and LCC / energy consumption, i.e. a higher comfort level would result in a more expensive cost and render the building consume more energy. Figure 5 shows both Pareto-optimal solutions (in red) and Non-Pareto-optimal solutions (in black) which demonstrates the power of MOGA in locating the Pareto-optimal solutions. Figures 4 and 5 both show the trade-off characteristic between LCC and energy consumption. From Figure 6, it can be observed that the initial generation of solutions is rather scattered while the last generation of solutions is more organized and converging towards the lower left corner of the plane. It is worth mentioning that all solutions in the last generation belong to the global Pareto front, which shows the optimization model's capability in fast convergence.

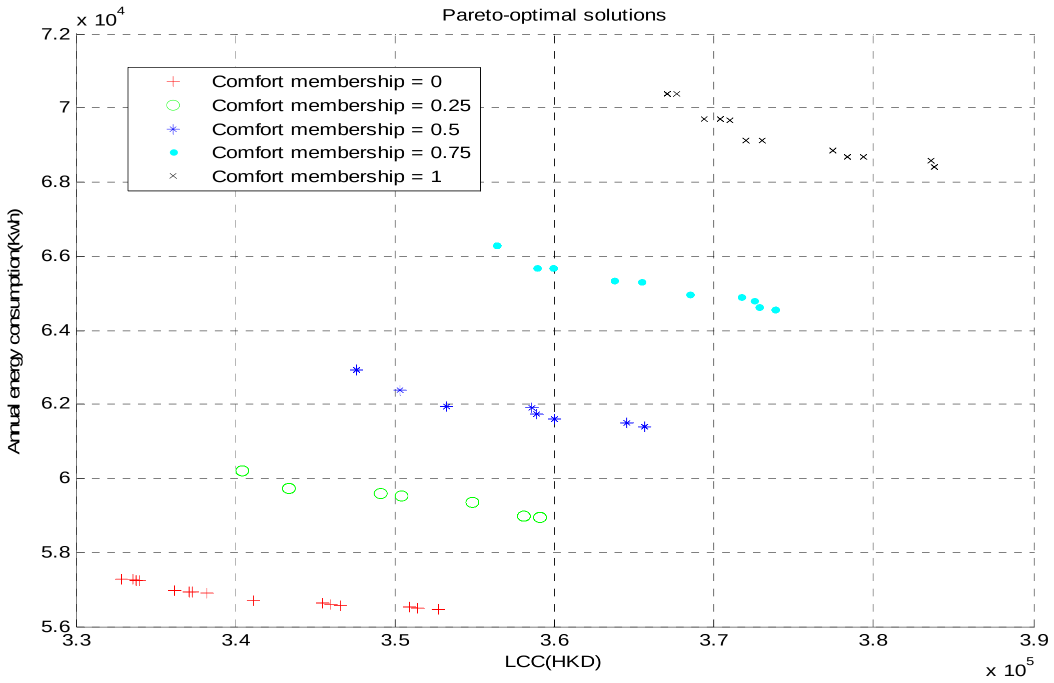

Figure 4. Pareto-optimal solutions from all the 1000 solutions

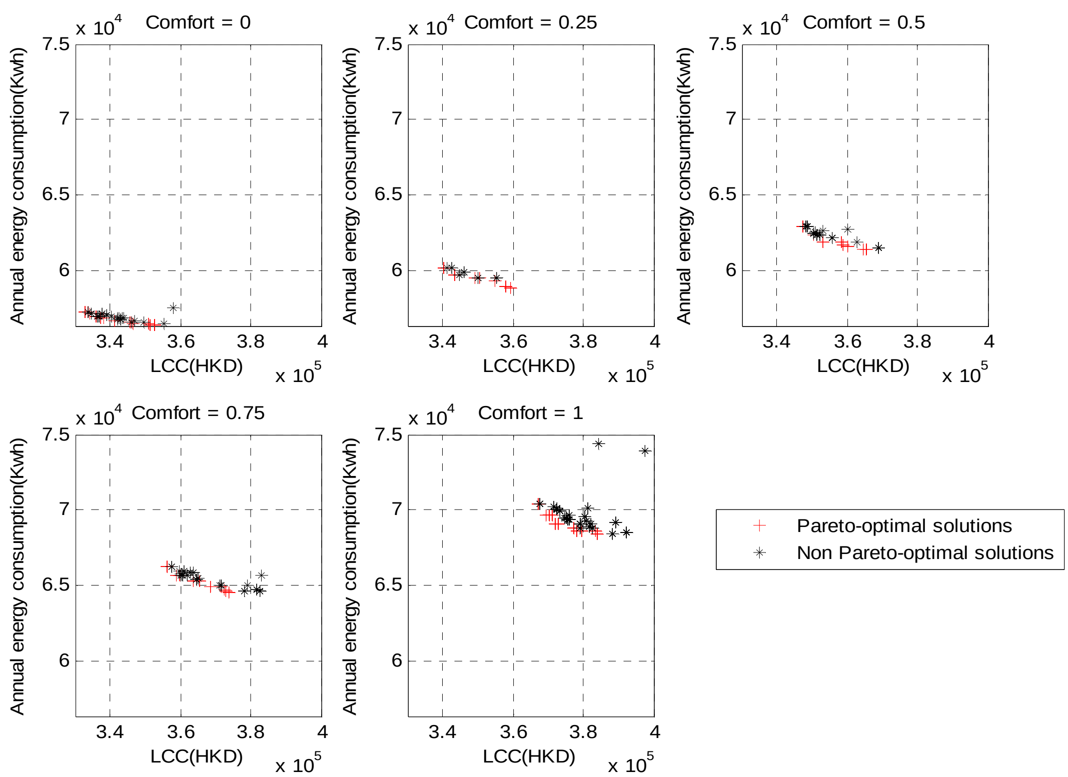

Figure 5. Pareto-optimal solutions vs Non-Pareto-optimal solutions

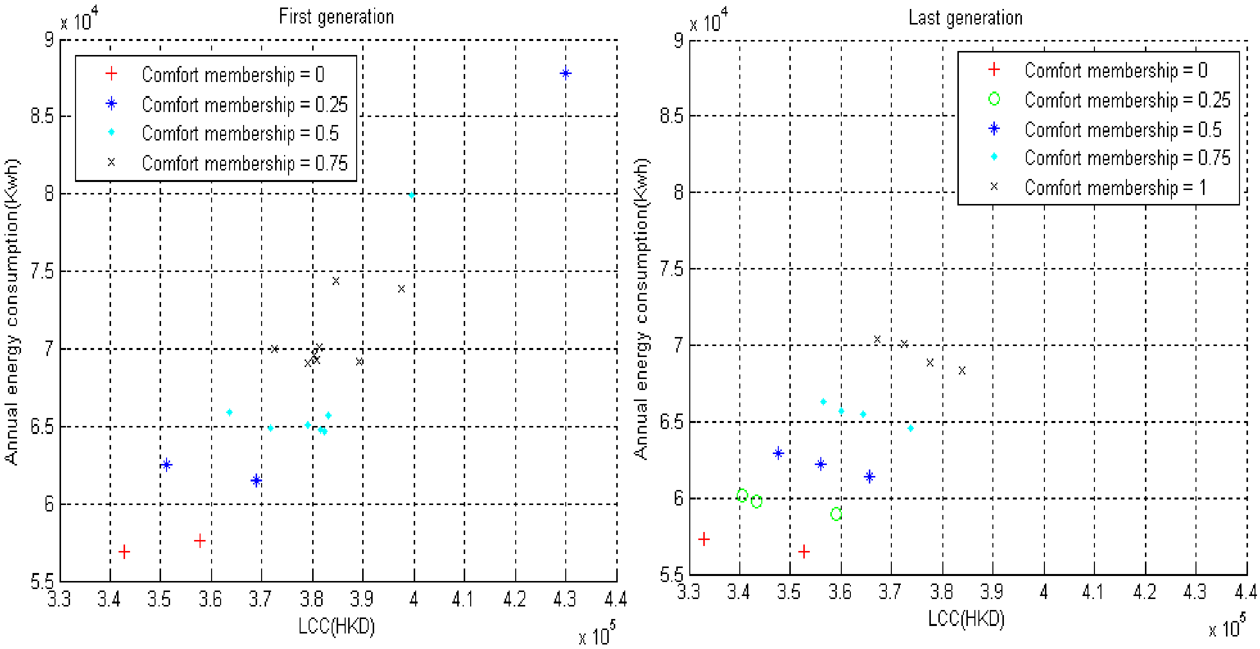

Figure 6. Solutions of the first and last generations

5. Conclusions

Cost, energy performance and end-users' comfort are the three key design criteria in sustainable building design. The multi-objective simulation model developed in this paper can assist designers locate global Pareto-optimal solutions in a fast and efficient manner during the conceptual design stage. Designers would be benefitted by having a clear picture on the trade-off characteristics among the three objectives. As more and more information on the requirements and constraints become available through the design process, the designers could make a further refined search within the Pareto front for the most desirable design solutions.

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Understanding the effect of transformation leadership behaviour of middle managers on innovation

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Abstract

The purpose of this study was to investigate the role of transformational leadership behaviour of middle managers in facilitating innovation in project based professional services firms. It followed a quantitative data collection and analysis to examine the relationship between transformational leadership and climate for innovation, innovation championing behaviour and project performance. In-depth interviews were held with 13 members of staff selected from different parts of the company. In addition a focus group discussion was held with 15 Technical Directors aimed at developing a deeper understanding of the processes by which middle managers influence innovation. Findings from the study suggest middle managers' transformational leadership impact project outcomes by helping to develop a climate for innovation and influencing the innovation championing behaviour of their staff through their actions and behaviour in the workplace. The findings contribute to a better understanding of the role of middle level leadership in project environment in facilitating innovation and improved performance and answer the call for more qualitative approaches to understanding the impact of leaders in project based organisations.

Keywords: Climate for innovation, innovation championing, middle managers, project based firms, transformational leadership

1. Introduction

Most firms in construction and other industries consider innovation as an important source of competitive advantage as it provides an avenue by which they can differentiate their products or services (Dulaimi, Nepal and Park, 2005; Kissi, Dainty and Liu, 2011a). Innovation is also important to addressing the criticisms directed at the industry for delivering products and services which fall below clients' expectation of quality, price certainty and assured delivery (Kissi et al 2011a; Lu and Sexton, 2006). The need for change is more urgent in view of the current economic circumstances which have seen many companies pursuing a dwindling number of business opportunities (Kissi et al., 2011a). Innovation in this paper has been defined 'as the generation or adoption of ideas; design concepts or delivery processes, new to the adopting organisation, which when implemented will yield a reduction in cost and/or time associated with project delivery and improve the quality of outcomes (Kissi et al., 2011a: 12). Studies have identified a number of factors both internal and external to project based organisations as influencing innovation. This study however focuses on the factors organisations have control over; the internal influencers. The primary internal factors have been identified as; leadership, climate for innovation and innovation championing, (Kissi et al., 2011a; Kissi et al., 2010). Leadership behaviour in general and transformational leadership in particular has long been considered an important individual factor that influences innovation and performance in the workplace (Keegan and Den Hartog, 2004). Whereas a number of studies have confirmed the positive impact of transformational leadership on innovation, most of them have focused on top managers and adopted quantitative approach, treating transformational leadership as a composite construct. Therefore they failed to capture how transformational leadership is practically exhibited in the project based environment.

The study forms part of an on-going Engineering Doctorate programme and follows two previous empirical studies examining the role of middle managers in improving innovative performance. The first was a case study of three innovations which identified innovation supporting behaviour of middle managers, innovation championing and climate for innovation as the key factors that influenced the innovation outcomes. The second study which was quantitative in nature identified a positive and significant relationship between transformational leadership, climate for innovation and innovation championing behaviour. In addition, it was found that transformational leadership influenced project performance directly and indirectly through climate for innovation and championing behaviour (Kissi et al., 2011a; Kissi, Dainty and Tuuli, 2011b).

This phase of the study was to test the validity and applicability of the model in project based organisations. In addition, the study aimed to examine the influence of the individual dimensions of transformational leadership on innovation and how they are practically exhibited in the workplace. The study further sought to identify the most influential dimension that managers could concentrate on developing in order to improve performance. Middle managers in this study are considered as those above first level supervision but below the senior managers (Dopson, Stewart and Risk, 1992). They include Technical Directors, Project Directors, Team Managers and Principal Engineers. Subsequent sections of this paper discuss the key constructs in this study, the methodology employed, the key findings and their theoretical and practical implications.

2. Transformational leadership

Transformational leadership is associated with stimulating and inspiring followers to deliver extraordinary results (Bass and Riggio, 2006). It changes followers by appealing to their higher order needs and causes them to modify their own values and to look beyond personal interest in favour of the group goals (Pieterse et al, 2010). Transformational leadership comprises several components, being a higher order construct (Pieterse et al, 2010). The study employed the six dimensions of transformational leadership; articulating vision, providing an appropriate model, fostering the acceptance of group goals, high performance expectations, individualised support and intellectual stimulation (Kissi et al., 2011a; Podsakoff et al., 1990). According to the authors through articulating vision, the leader identifies new opportunities for the unit and inspires others with his or her vision and shows them how to achieve the vision. The leader also provides appropriate model to the team of the sort of behaviour expected by living the espoused values as an example to the team. In addition the leader promotes team effort towards the achievement of organisational goals by fostering the acceptance of group goals whiles high performance expectation is reflected in the leader’s expressed confidence in the ability of the team to achieve. Moreover individualised support echoes the leader’s ability to consider individual team member concerns. Finally the leader challenges the assumptions employees have about their work and urges them to think outside the box in developing new solutions to existing problems through intellectual stimulation (Podsakoff et al., 1990, 1996).

3. Transformational Leadership, Climate for Innovation and Championing Behaviour

The way members of an organisation experience and react to their organisational context is referred to as climate (Rollinson and Broadfield, 2002). Climate in organisational studies is essential as employees’ draw conclusions from their observations rather than what is said and align their own priorities with what they perceive to be important to the organisations. Climate also determines the motivations, attitudes and behaviour of employees (Kozlowski and Hults, 1987; Kissi et al., 2009, Kissi et al., 2010). Climate for innovation is therefore considered as creating the kind of environment that will foster innovation in the work place. Leadership behaviour has the potential of influencing organisational climate. In a study of 1158 managers in Australian private sector organisations, Sarros, et al. (2008) found that visionary leadership associated with adequate supply of resources; funding, personnel, time for creative activities and reward for innovations influenced organisational climate for innovation. The study however did not involve a detailed investigation in context as it was quantitative in design.

The need for innovation champions in construction to improve performance has been well documented, (Nam and Tatum, 1997; Dulaimi et al., 2005). Innovation championing behaviour involves the project team members’ observable actions directed towards seeking, stimulating, supporting, carrying out and promoting innovation in projects (Dulaimi et al, 2005). Perception of the work environment has been found to impact on the creativity of individuals in the organisation (Amabile et al, 1996) and ultimately their innovation championing. Transformational leaders can enhance creativity and innovation in the workplace by developing an environment that encourages staff to pursue new approaches to resolving old problems without being apprehensive about recrimination in event of a negative outcome (Amabile et al, 1996; Kissi et al., 2011a; Kissi et al, 2009). This could therefore enhance the championing behaviour of the project team members. Ultimately Innovation championing behaviour leads to improved project performance (Nam and Tatum, 1997; Dulaimi et al, 2005, Kissi et al, 2010; Kissi et al., 2011a). However, most studies investigating the role of transformational leadership in facilitating innovation has been focused on senior managers at more strategic levels (Jung et al, 2008) or project managers, (Keegan and Den Hartog, 2004), with little attention paid to middle management (Kissi et. al 2010; 2011a). The role of middle managers in organisations has been subjected to a lot of debate and conjecture. Whiles some researchers suggest they have an important role to play in enhancing productivity through innovation, others argue that they are unimaginative, stubborn and don't have much to contribute towards the advancement of organisations (Huy, 2001; Kissi et al., 2011a).

From the forgoing, it could be seen that although there is significant empirical evidence that transformational leadership impacts on innovation, the role of middle managers in this process is debatable. Given that middle managers have a direct contact with and exercise supervisory responsibility over project teams, it could be argued that their day to day actions and behaviour in the work place could have a significant impact on how their team members respond and perform. For that reason this study is relevant to capturing how transformational leadership behaviour is practically exhibited by middle managers in the work place and how that impacts innovative performance.

4. Methodology

This phase of the study sought a deeper understanding of the process by which transformational leadership influence performance. There was no requirement to control the behaviour of the participants. The research questions posed were primarily "how and why questions". The study also aimed to develop a better understanding of the phenomenon within the context of a project based organisation. For the above reasons it was deemed important for the purpose of demonstrating how middle managers' day to day behaviour in the workplace influence championing behaviour, work climate and project performance to undertake in-depth interviews in context (Winch, 1998; Yin, 2003). Interviews therefore formed an important source of evidence in this study as they helped to focus directly on the topic and provided more insightful information (Yin, 2003).

The company on which the study was based employed about 8,000 staff across the UK, Middle East and Australia and operates in a number of industries. The study was based on the infrastructure Services Business Stream which primarily provides highway engineering and project management consulting services. A focus group discussion comprising of 15 Technical Directors (FG) and 13 interviews were held as part of the data collection exercise. The 13 interviewees comprised; 2 Team Managers (TM), 1Technical Director (TD), 1 Project Director (PD), 1 Principal Engineer (PE), and 3 Senior Engineers (SE) and 5 Engineers (CE). The average time spent per interview was about 40 minutes. The interview questions focused on the leadership behaviour of the managers they work with and how that influences their own responses and performance in the work place. In the case of the middle managers, the interview was focused on their own leadership behaviour and how that impacted on their team members' performance. The interviewees were selected to ensure that there was a representation from a cross-section of grades within the company.

The study adopted semi-structured face to face interview approach with guiding questions derived from literature. The interview focused on Podsakoff et al.'s (1990, 1996) six dimensions of transformational leadership as exhibited by middle managers. An example is 'how does your manager paint an exciting picture of the future to inspire you and the team'. Where the interviewees had not seen evidence of any particular dimension, they were asked about what the likely impact would be if their manager was to exhibit such behaviour. The study adopted the thematic approach to the data analysis following the recommendations of Braun and Clarke (2006) as briefly discussed below. All the interviews were recorded and transcribed verbatim. Using Nvivo version 9.2, initial codes were generated from the transcribed interview documents highlighting data which were of interest for further analysis. This was done in such a way to ensure that meaning was not lost by taking the data out of context. The next stage of the analysis involved combining the codes into appropriate themes and sub-themes. Following further analysis, the initial themes were refined to identify the key themes emerging. The final themes related to actions and behaviours of the middle managers which had significant impact on climate for innovation, championing behaviour and project performance.

5. Findings and Discussions

Findings from this research confirmed the positive relationships among the constructs observed in the earlier quantitative study. These relationships are diagrammatically represented in figure 1 below.

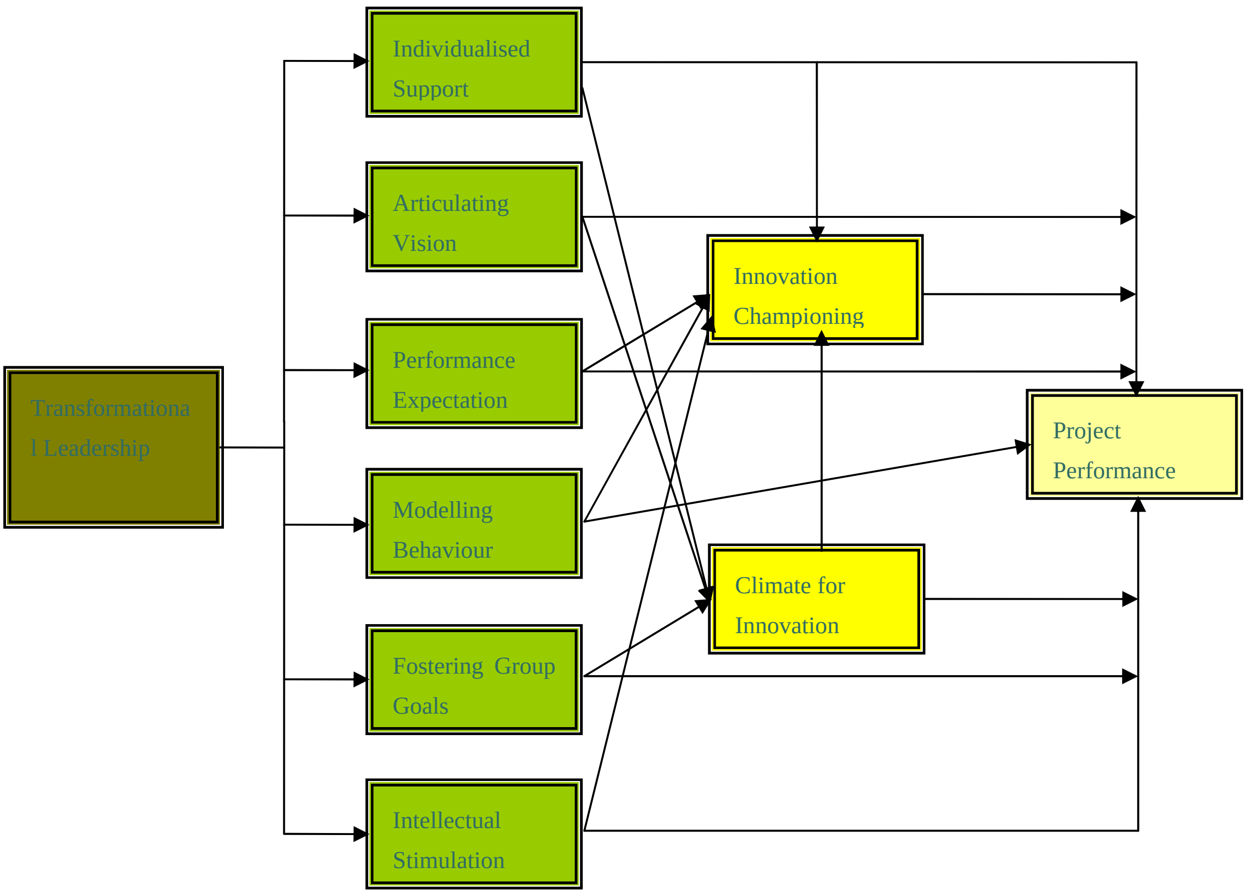

Figure 1: Relationship between individual dimensions of transformational leadership and the innovation championing, climate for innovation

This study found that individualised support was the most influential dimension impacting on innovation championing behaviour, climate for innovation and project performance. Articulating vision and fostering the acceptance of group goals both influenced climate for innovation and project performance. High performance expectation, modelling behaviour and intellectual stimulation influenced innovation championing and project performance. The study also found that climate for innovation influenced project performance directly and indirectly through innovation championing.

The study further identified the specific behaviours of the middle managers that were responsible for the relationships observed. For lack of space in this paper, the most influential dimension; individualised support is discussed in detail. Table 1 below summarises examples of the individualised support as reported by interviewees, the impact on team members and corresponding verbatim quotes in support of the impact. Details of the manifestations of the other dimensions of transformational leadership will be reported in the forthcoming Engineering Doctorate thesis. In the sections that follow, manifestations of the individualised support dimension are discussed in detail.

Table 1: Examples of transformational leadership dimension of individualised support and how it was expressed.

Transformational Leadership Dimension	*How it was expressed*	*Examples of such behaviour found*	*Impact*	*Quote where relevant*
Individualised Support	*Personal Development*	*Managers allocating projects that will help staff develop other skills*	*More commitment and improved performance*	*'feel good if you think you got an opportunity to develop and grow somehow it is good for you' (CE1)*
	Respect for Individual Preferences	*Managers respecting a particular individual's preference for e-mail communication instead of verbal*	*Perception of work environment is enhanced, people feel more relaxed, and output increased*	*'I work with other people that if I probably showed them I expect a lot from them I will get a negative response so I show them I am very pleased when you do your best' (FG1)*

5.1 Personal development

This was seen in the middle managers addressing the development needs of their staff. It was reflected in the manager making efforts to understand the strength and weaknesses of the team and helping the team members to harness their strength while developing other skills. The evidence suggested that some middle managers allocated projects to individuals that enabled them to address their personal and professional development needs. Some managers actively sought opportunities for their staff to work on specific projects with different clients and different parts of the business that could facilitate their development. In most cases this was possible because having built their careers over several years in the company most cases from the lower levels (Huy, 2001); the middle managers had extensive networks across the company that they drew support from in developing their teams. This according to the staff involved had a very positive effect and elicited extra effort from them. This finding is consistent with suggestions by Bass and Riggio (2006) that a core element of transformational leadership is to enable followers to develop their capabilities and their own capacity to lead. Similarly Sosik, Godshalk and Yammarino (2004), compared the effect of transformational leaders on their staff to that of mentoring which includes providing career development guidance. According to Bass and Riggio (2006:55); 'a major determinant factor of the effective performance of transformational leaders may be the extent to which the leaders are able to have a positive influence on followers' development'.

5.2 Respect for Individual Preferences

There was evidence to suggest that middle managers were conscious of and respected the individual preferences of their team members as evident in this statement by one of the Technical Directors, 'I work with other people that if I probably showed them I expect a lot from them I will get a negative response so I show them I am very pleased when you do your best' (FG1). Also commenting on intellectual stimulation the Technical Director stated that 'there is a group of people who need to do what they have always done so to go and talk to them why did n't you have that great idea is not getting the best out of them. So what you want is an environment where those who can think outside the box are encouraged to do so and are appreciated and those who have the job to put these ideas into action, their work is appreciated as well' (FG1).

Some managers also recognise that there are different insecurities and pressures and issues that affect their day to day performance and took this into consideration in working with them. An individual preference recognised and taken into consideration was seen to have a positive impact on the individual's motivation and commitment and which ultimately influences their performance. It was observed that middle managers were able to do this because of their closeness to the delivery teams unlike top managers. This finding is consistent with (Bass and Riggio, 2006) suggestions that transformational leaders can have a greater impact by recognising, accepting and working with individual differences and preferences of their team members which in turn influences the nature of the relationship between the middle managers and their team members. Similarly Scott and Bruce (1994) asserted that the quality of relationship that exists between employees and their managers, impact on their innovativeness as it influences the subordinate's perception of the work environment as supportive.

5.3 Challenging Work

The study found that middle managers' effort in packaging work and allocating new challenging roles to individuals did have a positive impact on their work environment and they had more job satisfaction as a result. One Technical Director commented that 'you will have noticed people have been given new roles for example someone is made a team manager or another office, you can see that all of a sudden, he starts coming to the office at 7:30 in the morning and he is running around and he is working very hard and he is doing that because he is happy, he is happy and he is happy because he is stretched and he is challenged and he has challenges to face' (FG2). Middle managers were seen to draw extensively from their years of experience when packaging work for their team members and asking challenging question. Some of the staff were seen to make the extra effort in undertaking research and finding solutions to challenging tasks or projects they had been allocated leading to increased championing behaviour and higher levels of performance. This could be explained by the fact that some people are motivated by the nature of the task or the role assigned to them in the work place (Rollinson and Broadfield, 2002). Moreover in a professional services environment challenging work could stimulate professional development and higher levels of performance, (Keller, 1992). Shalley and Gilson (2004) similarly submitted that when managers provide a challenging environment to employees it informs the perceptions of the work environment as one supportive of innovation which influence innovative behaviour in the workplace.

5.4 Interaction and Feedback

The study showed that team members whose managers were approachable and accessible had a good experience of the work environment as being supportive and influenced their tendency to adopt innovative solutions. This could be seen in informal chats among the middle manager and the team members on social issues, sports and other activities outside work. The need for this interaction was expressed by one interviewee, 'managers need to have more of an office presence rather management meetings and need to spend more time interacting with their teams to get to know them not just by filling in skill matrix but get to know their teams and their skills and what they are excellent in and what their limits are' (PD1). This statement further buttresses the fact that staff expects their managers to engage and interact with them. Where there was more regular interaction, team members were able to bounce ideas off their managers and that was seen to encourage team members to make efforts to adopt more innovative approaches to delivering projects (Salter and Gann, 2003).

The study further found that these regular interactions also afforded managers the opportunity to provide more regular feedback to their staff. Providing regular feedback was seen to have a positive impact on the staff as that put them in a position to understand where they were contributing to the expected level required of them and where they needed to do more. Feedback was seen to include both positive when a good work was done and constructive criticism where work delivered was not up to the standard expected. Both were seen to lead to improved performance. The findings further suggest that the more personal contact between the middle manager and the delivery teams and resultant interaction tends to create an atmosphere of trust enabling the teams explore and develop solutions as innovation champions (Kissi et al., 2011a).

5.5 Support for Individuals

There was evidence to suggest that where middle managers provided support and stood by staff in good and bad times and provided advice for them when problems were presented to them, it created a sense of a good place to work. According to one of the interviewees it made the staff feel they were in the right place. Some of the interviewees stated that they had no problems at all approaching their managers with personal concerns as they were always understanding and supportive. The positive effect of this was re-echoed by one of the interviewees who commented that ‘when you treat your employee as a human and care about them in their personal life as well as their work life then they get attached to you and they want to stay with you and they want to do their best for you’ (CE2). It could therefore be seen that paying attention to the individual’s needs does not only influence the environment within which people operate but also their motivation to work harder on their projects. An interviewee cited an instance when due to personal circumstances had to work from home and how the manager was very supportive in allowing work to be done around the circumstances as far as the expected targets could still be achieved.

Managers’ action in listening and taking the needed actions to address the concerns of staff was seen to have a positive impact. The team members had a favourable view of managers who forwarded issues to other people better placed to deal with them in the event that they were unable to deal with them. However the findings suggested that listening and not taking action had a negative impact on the staff. By their closeness to the staff, middle managers were able to provide a safe psychological environment or work climate for members of their team trying new approaches and developing new solutions to existing problems (Huy, 2001). Providing support for individuals has been found to lead to higher levels of productivity, (Podsakoff et al., 1996). Similarly, Oldham and Cummings (1996) found that employees were at their most creative when they operate in a supportive environment. It’s however worth noting that in an environment where people value their independence, over stretching support for the individual could be misinterpreted to mean the manager lacks confidence in the individual’s ability to deal with their own issues (Keller, 1992) and could lead to negative outcomes.

5.6 Recognition

The study found that when individuals were recognised for their contributions to project delivery, made to have a sense of belonging and seen as valued members of the team, their confidence and motivation were positively influenced to do more. In a particular instance one of the interviewees undertook a project which won an award and this information was circulated in the division. Asked how that impacted his work, he responded that made him feel good and wanted to do more. One interviewee commented that ‘he looks at the good things that you have done rather than the negatives. That motivates you to do better. There is always that you have n’t done, you cannot always get 100% so if you get 90% he focuses on the 90% instead of the 10%’ (CE4). Recognition has been previously identified as an important motivating factor in a number of studies, (Rollinson and Broadfield, 2002).

6. Conclusion

The purpose of this study was to examine the role of middle managers in enabling innovation in project based organisations. The study investigated the behaviours middle managers exhibited in the work place and how that influenced the performance of their teams. This paper focused on identifying the specific behaviours that comprised transformational leadership dimensions of individualised support and the impact on team members. Findings from the study suggest that middle managers can demonstrate individualised support by; assisting the personal development of staff, providing support for them in time of need, taking their preferences into consideration in working with them, providing challenging role, recognising their contribution, providing regular feedback and having regular interaction with their team members.

These were seen to impact the team members in diverse ways. Firstly, it influenced their perception of the climate within which they operated as supportive of innovation. Secondly it influenced their tendency to exhibit innovation championing behaviour by enhancing their tendency to adopt innovative approaches to delivering projects. Climate for innovation and championing behaviour were also seen to influence project performance as team members were motivated to undertake extra role activities in project delivery. Individualised support therefore influenced project performance directly and indirectly through climate for innovation and championing behaviour.

The findings have a number of significant implications for project based professional services firms. Whereas most efforts at enhancing innovation is focused on senior management, this study demonstrates that middle managers who bridge the gap between the strategic and operational levels in the organisational structure have a very important role to play in facilitating innovation through their day to day activities and the behaviour they exhibit in the work place. To enable middle managers to play this role effectively, they need to be supported to develop transformational and innovation supporting leadership behaviour. In the current adverse economic conditions, there is a tendency for middle managers to bear the brunt of cuts. However that could lead to loss of very valuable experience and an important resource for improving performance. The role of middle managers in enhancing innovation needs to be recognised and promoted to help address the previously reported negative reviews on the role of middle managers in organisations.

In spite of the significant findings in this study, it is not without limitations. The study was focused on one organisation. However the size of the organisation and the number of industries it operates in implies the findings from the study will be relevant to several other similar organisations. Future studies could be extended beyond the current organisation to others in the industry. Future studies could also adopt a longitudinal approach focused on developing transformational leadership in middle managers and studying the impact over time. The study has introduced a new dimension of the study of the effect of transformational leadership by examining the impact of specific dimensions on performance which could be investigated further in the wider industry context.

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Participation and collaboration in construction projects: Exploring Stakeholder Integration Champions and legitimacy

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Abstract

It is well known in the fields of architecture and urban studies that the participation and collaboration of project stakeholders have important effects in both the process of project development (for instance the social capital that is created) and the quality of the final product - the built environment. However, little is known about the legitimacy of the participation of such stakeholders; more particularly, about how the legitimacy of stakeholders is taken into account when deciding who participates and collaborates. This research gap leaves unanswered several questions that are crucial for professionals working in architectural and urban projects of public interest: Who determines who is a participant in project decision-making and how do they perceive and take into account the legitimacy of these stakeholders?

This exploratory study permits to clarify the context in which the legitimacy of stakeholders is taken into account in decision-making. Theories borrowed from organizational science show that the level of legitimacy of an actor within a social system is created by the perception of two kinds of attributes: expectations and capacities (resources, authority, legal rights and expertise). An empirical study based on a case survey was conducted. Results show that there are several actors who act as Stakeholder Integration Champions and who have a crucial role in determining who becomes a legitimate participant and the context in which expectations and capacities are integrated in project decision making. However, these integration champions do not all operate in the same manner, and therefore a categorization of them is presented. This exploratory study proposes a framework for the analysis of stakeholder legitimacy; in doing so, it also proposes several research questions that must be addressed in future studies.

Keywords: Stakeholders, Legitimacy; Project governance, Integration champions, Projects of public interest.

1. Introduction

There is a consensus that stakeholder involvement increases the performance of both the project process and the outcome. This argument has been largely validated in project management in general (Freeman, 1984; Friedman & Miles, 2006; Steiner, 2008) and in the construction sector in particular (Chinyio & Olomolaiye, 2010; Olander & Landin, 2005; Walker, 2008). Reasonably, there is a growing interest in stakeholder collaboration and participation in the building sector: “Relationships are clearly a critical factor in delivering successful projects, yet paradoxically relationships are infrequently managed.” (p.11) (Pryke & Smyth, 2008). Stakeholder involvement becomes even more relevant in the case of *construction projects of public interest*, namely, public or private initiatives that have a direct effect in the general public. They include facilities for public services (universities, hospitals, governmental offices, etc.), and urban projects (parks, squares, projects of urban revitalization, etc.). These two types of projects – albeit different in scale and complexity – often involve a great number of stakeholders with divergent and contradictory claims and interests. In this context, stakeholder participation and collaboration – it is often argued - is crucial for “widening stakeholder involvement beyond traditional power elites, recognizing different forms of local knowledge, and building rich social networks as a resource of institutional capital through which new initiatives can be taken rapidly and legitimately” (p. 1531) (Healey, 1998). This objective has led to accept that “legitimate and valid stakeholders need to be identified and their power and influence mapped so that their potential impact on projects can be better understood” (p. 651) (Bourne & Walker, 2005). However, this statement poses more questions than answers. In fact, *who* needs to identify and involve these ‘legitimate and valid’ stakeholders? *How* are stakeholders involved and their legitimacy perceived taken into account?

This article explores the context in which the participation and collaboration of stakeholders is developed, while doing so it explores the concept of legitimacy, notably it addresses how the legitimacy of stakeholders is taken into account in order to determine their involvement in project decision making. The first section introduces the concepts of collaboration and participation. Theories borrowed from organizational science and philosophy are then used to explain the legitimacy of an actor within a social system. It finally explains the concept of Stakeholder Integration Champion. The second section presents the methods used in the empirical study. The “results” section shows that there are several actors who play a crucial role in determining who becomes a legitimate participant. Finally, discussion of these results and the findings of the article are presented in the last section.

1.1 Participation and collaboration in projects of public interest

Several definitions of project stakeholders exist; yet for this analysis we adapted the definition proposed by Freeman (1984) and thus we argue that a stakeholder corresponds to any group or individual who can affect or is affected by the project. By adopting this definition we acknowledge that stakeholders include both players who directly act in the project and individual and groups that are affected by the work of those players. It is therefore possible to distinguish two types of relationships between stakeholders: (a) *Collaboration*, which refers to the relationships between stakeholders who share a similar level of responsibility and authority (most often between professionals, or between them and contractors); and (b) *Participation*, which refers to relationships between stakeholders that do not necessarily have the same level of authority and responsibility, notably the external participants that are not directly engaged in the design or construction of the project (residents, users, neighbors, members of the civil society, pressure groups, etc.). There are multiple types and levels of collaboration (Bouchlaghem, 2012; Kvan, 2000) and participation (Arnstein, 1969; UN-Habitat, 2009). Yet we will not address their different levels of intensity as it is out of the scope of this article.

1.2 Legitimacy of project stakeholders

Theories borrowed from organizational science claim that a stakeholder can be characterized by the combination of three attributes: its expectations toward the project, its capacities (material or immaterial) and its actual actions towards the project (Freeman, 1984; Mitchell, et al., 1997b). In sociology, the legitimacy of an entity depends on conformity to both the law and the desires of the society at large (Suchman, 1995). Philosophers believe instead that it depends on conformity to reason (Duran, 1990). In the context of this article, legitimacy corresponds to the quality that is recognized – albeit subjectively – in a stakeholder whose actions are pertinent within a project context. Considering that the actions of a stakeholder are based on its expectations and capacities, it is possible to argue that its legitimacy to intervene in a project, as a participant or a collaborator, may be attributed according to its expectations towards, and its capacities within, the project. Together, they become the attributes upon which legitimacy is recognized.

Based on early contributions on the concept of legitimacy (Weber, 1947), and more recent studies on stakeholder management (Freeman, 1984; Mitchell, et al., 1997a; Suchman, 1995), we can distinguish different kinds of expectations and capacities. Expectations can be rather high or rather low, implicit or explicit, conscious or not, immediate or long-term, perceived only by an individual or by the society as a whole. We also identify four kinds of capacities. First, material or financial capacities, as in the case of resources provided by a project sponsor. Second, recognized authority, obtained for example from democratic elections or charisma-based leadership. Third, legal rights, including privileges, titles and contractual links (for an example, the right of the municipality to expropriate a landowner, or a client who signed a contract to obtain a service). Fourth, the expertise, for instance, users' expertise or the knowledge and experience of a professional that works in the project.

1.3 Stakeholder Integration Champions

Individual organizations and teams often benefit from individuals or groups who act as project leaders and enhance the participation and collaboration of stakeholders. They are often referred to as integration champions (Calamel, et al., 2011; Hoegl, et al., 2004) or as relationship promoters (Walter & Gemunden, 2000). They are responsible for (or assume the role of) fostering integration, facilitating communication, exchanging information and creating the conditions for the emergence of innovative solutions (Hartmann, 2008). They also play a crucial role in the integration of the supply chain and in enhancing inter organizational participation and collaboration. They "identify appropriate partners of different organizations, bring them together, and facilitate the dialogue and the exchange processes between them [they] solve inter-organizational conflicts [and thus] fulfill an important social task" (p. 86) (Walter & Gemunden, 2000). However, construction projects are a bit different; they do not involve a clear team leader. Moreover – technically - construction project stakeholders do not constitute a 'team' but a 'Temporary multi-organization" (TMO). As such, they do not have a single authority responsible for the project but a group of heterogeneous organizations, gathered around a project promoter (often the owner), and mobilized to collaborate temporarily to achieve the project goal. Yet, this dos not mean that authority and decision-making power is equally distributed among all the stakeholders (Viel, et al., 2012 (à paraître)). In fact, some authors have found that there are also integration champions within the construction sector (Hartmann, 2008). We will refer to them here as 'Stakeholder Integration Champions'.

2. Methods

We conducted an exploratory work based on a case survey and literature review. The aim was not to provide final answers but to identify valid and relevant research questions for further analysis. During this work we were able to narrow the scope of the study and propose two initial research questions: *Who* determines the level of participation and collaboration of stakeholders in projects of public interest? *How* legitimacy is taken into account when a certain type of actor is responsible for - or assumes the role of - integrating other project stakeholders?

The survey was supported by a database of case studies conducted by our team during the last five years. By January 2012 this database had published 45 peer-reviewed case studies of projects or architecture and urban design in Canada (provinces of Quebec and Ontario). The cases were conducted by teams of graduate students within a period of 3 to 5 months and they were based on primary data, observations and two to six semi-directed interviews conducted with project stakeholders. Primary data includes budgets, project reports, construction schedules, construction documents, photos and press releases. Following Proverbs and Gameson (2008) and Yin (2003), we used various sources of information for triangulation, comparing printed data with qualitative information obtained from the interviews. The quality of the cases was validated by a peer review process in which an external expert and two reviewers were asked to assess the reports and to suggest improvements or reject the reports. The database includes only accepted and amended reports. All the reports follow a rigorous structure of analysis that included the identification of: (a) the project management methods following the nine knowledge areas proposed by the Project Management Institute (PMI, 2008); (b) the characteristics and strategic objectives of relevant stakeholders; (c) the procurement strategy of the project; (d) the project life cycle; (d) the organizational structure of the project; and (e) the main issues affecting the feasibility studies (including issues of innovation or technical challenges faced).

The database contains a wide range of projects executed within the last ten years and having different: uses (residential, education, religious), clients (private, public, mixed), funding options (private, public, mixed), interests (profit-oriented, non-for-profit initiatives) and scales. The identification of Stakeholder Integration Champions followed four iterative steps. In the first one we identified a reduced number of examples (projects) in which champions fostered collaboration and/or innovation. Secondly, we identified similar cases of champions that respond to the characteristics of the ones identified in step 1 (this was the first attempt of generalization). Thirdly, we revised the list of examples reading their characteristics under the light of possible generalizations. In the fourth step we generalized the characteristics of the types from the results obtained from the examples. We repeated this process three times before producing the typologies presented here. Please note that additional results of this project and this classification were also published in the conference (reference temporarily eliminated for peer review process).

3. Results and Discussion

Several authors have previously noted that construction clients determine the most important characteristics of the TMO (Brandon & Lu, 2008; Cherns & Bryant, 1984; de Blois, et al., 2010; Green, 1996; Nahapiet & Nahapiet, 1985). By having an important authority on decision making (notably through the procurement strategy) clients create the conditions for the participation (or not) of external stakeholders and for the level of collaboration between internal ones (Davidson, et al., 1997; Rowlinson & McDermott, 1999). Our first finding reinforced this argument; however, we also found that determining the level of participation and collaboration of stakeholders might often surpass the influence of the construction client (the owner). In fact, Stakeholder Integration Champions play a fundamental role in it – yet these champions might or might not correspond to the project client. Instead, they can be delegated by the client in an attempt to integrate stakeholders and contribute to improve their relationships; or they can emerge naturally and even help create the TMO and the client organization itself. More specifically, we found that there are different types of Stakeholder Integration Champions and that they develop different mechanisms to mobilize the participation and collaboration of stakeholders. Table 1 presents the types that we identified and the most important examples of organizations and projects that helped us create the typology. A detailed analysis of how their existence influences the way in which stakeholder legitimacies are taken into account is then presented.

Table 1. Types of Stakeholder Integration Champions, examples, projects and characteristics. .

	Type	***Example***	***Project***	***Involvement in***	
				Collab.	***Particip.***
1	*Mediation Partner*	*Convercité*	*Benny Farm*	*x*	*x*
2	*Integrated Client Team*	*NFP Corporation Client*	*Maison du DD*	*x*	
3	*Delegated Project Manager*	*QIM*	*Quartier des spectacles*	*x*	*x*
4	*Community Support Org.*	*GRT*	*Logements Bellechasse*	*x*	*x*
5	*Design Integration Team*	*Consortium de design*	*Complexe sportif NDG*	*x*	
6	*Project Integration Team*	*Partenariat Public-privé*	*Centre des arts Shenkman*	*x*	
7	*Participation Organizer*	*OCPM*	*Musée des beaux arts*		*x*

1. Mediation Partner: This type of champion accompanies the client since the early stages of the project and contributes to create the proper conditions for collaboration and participation between stakeholders. Its main role and strategy is to mediate between them, acting as a partner that can reach consensus and alignment. This champion leads collaborative processes within community groups, and between stakeholders, professionals and the client, notably for the definition of the project's objectives and program. A clear example is Convercité, an organization that is involved in "complex urban challenges, sensitive subject matters or multi-stakeholder projects". Its strengths lie in « its ability to foster dialogue and cooperation through a flexible, yet rigorous approach focused on

concerted action ». Its mission includes not only contributing to the project itself but also to the consolidation of the social environment around the project, covering social environments and the understanding of the contexts and dynamics that drive them. It also coordinates the preparation of the site development plans and may support the client through the process of approving and obtaining municipal zoning changes. Its activities include census and data analysis, surveys, interviews and consultations with key stakeholders, including end-users, the community and the client. This includes organizing various public presentations and soliciting feedback from the community via meetings and websites (Convercité, 2012).

2. Integrated Client Team: This type of champion integrates several stakeholders in order to create a stronger project client capable of commissioning larger and more ambitious projects, sometimes with higher levels of innovation. By acting in a collaborative way with other partners (both financial partners and professionals), this champion obtains additional resources and mobilizes enough interest and expertise around the project. Examples include the Centre for Sustainable Developpement is a complex client composed of eight non-for-profit organizations which gathered together to develop a green building aimed to become an example of sustainable development practices (The Centre for Sustainable Development, 2012).

3. Delegated Project Manager: This type of champion acts as a partner and a delegated project manager of public entities (for example municipalities) in order to conduct large urban interventions and other complex projects of public interest. This champion aims at integrating heterogeneous stakeholders and developing a consensus around the objectives of the project, often by the means of activities of collaboration. They begin their participation early in the project and conclude their role during the transfer of the project to the client, becoming in this way a pivotal hub of information during the whole project life cycle. These champions assume the role of identifying stakeholders and developing tools and methods to facilitate communication between them. For instance, the Society QIM is a small size organization that offers services of project management; its mission includes catalyzing public and private investment in projects of public interest and managing all aspects of project management, from procurement to stakeholder management The Board of Directors includes representatives from different partners, including the municipality, a public investor, a provincial ministry and private stakeholders. This organization is recognized for its experience in innovative methods of collaboration such as "partnering" and "visioning". (Société Quartier International de Montréal, 2012).

4. Community Support Organization: This type of champion acts as an intermediary between individuals or groups interested in developing social or community projects, and public organizations. They facilitate the development of socially and economically viable projects of public interest. These champions integrate stakeholders in order to develop social projects. Their roles include creating or consolidating the client organization, for example stakeholder cooperatives. Examples in Canada include the Quebec's Technical Resources Groups, which act as partners of the city and the government in order to implement housing programs. These champions contribute to the creation of housing cooperatives and accompany them through the process of obtaining public subsidies and financial assistance for the project. They offer technical support to conduct a "democratic" process integrating three levels: social development, real state development and financial feasibility

(l'Association des groupes de ressources techniques du Québec, 2012). They create innovative financial structures, collaborative methods, and architectural solutions that often differ from the profit-oriented solutions proposed by residential developers.

5. Design Integration Team: This type of champion is not a single organization but private design consortiums created for the development of complex projects. Design consortiums seek to integrate professionals in order to respond to technical challenges and complex demands in tendering processes. However, their collaborative spirit might contribute to other ends, including integrating stakeholder needs and creating innovative solutions. As an example, consider the design consortium involved in the complexe sportif NDG. It is composed by two architectural firms, a landscape architecture firm, a project management and engineering firm and a mechanical engineering firm. In a recent case, community groups opposed the project designed by the consortium because of its impact on an open area of the neighborhood. In response, a committee for the creation of the technical project brief was created including participation of local residents. The integration of professionals facilitated the use of prefabricated components, the decision to build some sections of the building in underground spaces (to reduce the impact of the building) and the adoption of an environmental certification.

6. Project Integration Team: This type of champion is also a consortium of multiple companies but it includes not only design firms and consultants but also other partners with financial, managerial and construction credentials. These consortiums are usually created to respond to Public-Private Partnerships (PPPs) or Design-Build contracts in which professionals of design and builders work in a concerted manner within one single contract signed with the project client. The consortium often has multiple mandates that are unusual for most construction and design companies: to finance, to transfer the facility, to own and operate the facility, or to act as a land developer. These consortiums are characterized by higher levels of integration between (a) designers and builders with stakeholders having financial, legal and managerial expertise; and (b) public and private partners. Multiple examples of PPP exist now in Canada, including the The Orléans Town Centre Partnership is led by Forum Leasehold Partners Inc. and includes a construction company, an architectural firm and engineering firms. Joint ventures were created with other residential developers and builders for specific aspects of the project (Ottawa City, 2012). Its role includes operating facilities and acting as a land developer.

7. Participation Organizer: This is a non-for-profit type of C&I champion that organizes public participatory debates on architecture and urban projects of public interest. Based on the consultation of the public, its recommendations may have a high influence on project approvals. This champion does not facilitate collaboration per se. However, it does develop participatory mechanisms to give voice to all project stakeholders. The objective is to establish credible, transparent and effective consultation mechanisms for projects of public interest. There are not many examples of this type, but we considered the Office de consultation publique de Montréal, a non for-profit organization that organizes public consultations for projects of public interest. This champion encourages participation, facilitates access to information for the citizens, and produces a report that acts as a recommendation for all stakeholders. It acts as an independent organization, a neutral third party between the public, the city and developers (Office de consultation publique de Montréal - OCPM, 2011).

In order to understand how stakeholders’ legitimacies are taken into account by these Stakeholder Integration Champions, it is important to examine their differences and similarities. The first difference concerns their scope of intervention in the project. In fact, we found that all, except type 7, contribute to collaboration between internal stakeholders. Types 1, 3, 4 and 7 facilitate participation of external stakeholders (see table 2).

Table 2. Types of stakeholders involved in different project phases.

	Type	***Types of stakeholders integrated by the champion during each phase***						
		Concept	***Planning***	***Design***	***Approvals***	***Procur.***	***Const.***	***Closing***
1	*Mediation Partner*	*ES, CO*	*ES, CO*	*ES, CO, BS*				
2	*Integrated Client Team*	*CO*	*CO*	*CO*	*CO*	*CO*	*CO*	*CO*
3	*Delegated Project Manager*		*ES, CO, BS*	*ES, CO, BS*	*ES, CO, BS*	*CO, BS*	*CO, BS*	*CO, BS*
4	*Community Support Org.*	*ES, CO*	*ES, CO*	*ES, CO, BS*	*ES, CO, BS*	*CO, BS*		*CO, BS*
5	*Design Integration Team*			*BS*				
6	*Project Integration Team*	*CO*	*CO*	*CO, BS*	*CO, BS*	*CO, BS*	*CO, BS*	*CO, BS*
7	*Participation Organizer*				*ES*			

** External stakeholders (ES); Internal to the client organization (CO); Building sector stakeholders (BS).*

The second difference concerns the types of stakeholders that they involve and the phases in which they do it during the project life cycle. In order to do this we used the classification of stakeholders proposed by Lizarralde et al. (2011), which identifies three main groups with various subgroups: First, external stakeholders: including users, external pressure groups, control agencies and sponsors. Second, stakeholders internal to the client organization, including internal procurement, funding and operation units, sometimes professionals of design, and in the case of a public body, elected officials. Finally, building sector stakeholders, including design agencies, management consultants and construction companies. Stakeholder Integration Champions largely decide who participates and collaborates; by doing so, they also exclude other stakeholders and determine the conditions in which integration is conducted. Table 3 shows that types 1, 2, 4 and 6 participate in the whole life cycle – in all phases, namely: initiation, planning, design, approval, procurement, construction and closing. Instead, the Participation Organizer (type 7) has a limited intervention in the approval phase and concerns only external stakeholders, when projects are subject to public debate. The Design Integration Team (type 5) acts mostly during the design phase, integrating mostly building sector stakeholders.

The third difference relates to the attributes (expectations and capacities) that are naturally taken into account by the different mechanisms of collaboration and participation deployed by the Stakeholder Integration Champions (Table 4). Types 1, 2, 4 and 7 integrate project stakeholders, through participation or collaboration processes, in order to identify and take into account their expectations. This is not the natural objective of design integration activities led by type 5, though this champion deals with stakeholders’ expectations through the design process. Types 3 and 6 do not promote participation per se and thus identifying expectations of external stakeholders is not a central motive in their actions. Material and financial resources are key capacities for integration activities promoted by types 2, 3, 4 and 6. Though all types may empower stakeholders with a recognized authority (e.g.

charisma), types 2 and 3 specifically resort to the integration of elected officials (a kind of recognized authority) in their activities. Although legal rights are a source of legitimacy that all types of Stakeholder Integration Champions must respect (by law), it is a central one for types 1, 4 and 7, whose role is precisely to promote some of these rights (for example, the citizens' right of expression). Eventually expertise is a key attribute recognized by all Stakeholder Integration Champions, but in different ways: types 2, 3, 4, 5 and 6 rely on the professional expertise of managers, designers, or builders, while types 1, 3, 4 and 7 promote users' expertise through participation processes.

Table 3. Attributes recognized by the mechanisms deployed by Stakeholder Integration Champions

	Mechanisms deployed by:	***Expectations***	***Capacities***			
			Resources	***Recognized authority***	***Legal rights***	***Expertise***
1	*Mediation Partner*	*x*			*x*	*x*
2	*Integrated Client Team*		*x*	*x*		*x*
3	*Delegated Project Manager*	*x*	*x*	*x*		*x*
4	*Community Support Org.*	*x*	*x*		*x*	*x*
5	*Design Integration Team*					*x*
6	*Project Integration Team*		*x*			*x*
7	*Participation Organizer*	*x*			*x*	*x*

The results shown in table 3 need three additional explanations. First, attributes are taken into account to a certain amount in each type. For example, not only those involved into participation processes, but all Stakeholder Integration Champions give place to legal rights: for instance the legal right constituted by the contractual link between partners mobilized by types 2, 5, and 6 is a strong source of the legitimacy of their participation. Similarly, even though meeting external stakeholders' expectations is not necessarily a central rationale of a project integration team (type 6), it is clear that not doing so may well lead to project failure; naturally, stakeholders' expectations are always taken into account to a certain extent.

Second, various Stakeholder Integration Champions may participate in a single project and integrate different kinds of legitimacies. For example, in order to deliver a major urban design project, a municipality and a provincial government may create an integrated client team (type 2), hire a delegated project manager (type 3), whose role would include the recourse to a mediation partner (type 1) early in the project, to a design integration team (type 5) during the design phase and to a participation organizer (type 7) before project approval. However some types of Stakeholder Integration Champions are less compatible with others, such as the case of a PPP (type 6): though this model calls for material and financial capacities and professional expertise, critics of PPPs have questioned their capacity to take into account legitimacies based on expectations (as this type is rarely associated with a strong public participation) and elected authorities (as this type implies a transfer of much of the decision-process to the private partner) (Hamel, 2008; Noble, 2006). Third, the attributes identified here can be subdivided into additional subtypes. For example, *expertise* could be subdivided into users' expertise and professional expertise. Moreover, all types and subtypes of attributes may be subdivided into two categories; weather the legitimacy concerns the Stakeholder Integration Champion itself, or the other stakeholders. For example, the expertise of a delegated project manager is an attribute of legitimacy for himself, whereas users' expertise promoted into a participation process organized by this delegated project manager is a source of legitimacy of external stakeholders. In both cases, type 3 involves legitimacies based on expertise.

Limits of the study

This is an exploratory study which aimed at identifying valid research questions; in fact, several of them still remain to be investigated: How conscious are these champions of the legitimacy of stakeholders while selecting who participates and collaborates in the project? What variables influence the decision of inviting stakeholders to participate in the project? How are legitimacies perceived differently in different countries and contexts? Other limits also exist. The first one concerns the legitimacy of Stakeholder Integration Champions themselves. According to Kliem, "persons in a position of formal authority can exercise power due to their legitimacy within the organization" (page 8) (Kliem, 2012). However, we did not explore in detail here the legitimacy of these champions. Secondly, the survey is limited to projects located in Canada – yet we believe that the transferability of results might allow for prediction and anticipation in other cases (results, however, cannot be generalized without considering additional patterns in other contexts). Finally, our cases do not exemplify all the possible variations of Stakeholder Integration Champions that might exist. They 'just' illustrate a comprehensive representation of them and permit to understand how they influence both participation and collaboration.

4. Conclusions

This article explored the context in which collaboration and participation are developed within construction projects of public interest, that is, public or private initiatives that have a direct effect in the general public. In order to do so we conducted a case survey of projects in Canada. The results permitted to answer two research questions. The first question aimed at identifying *who* determines the level of participation and collaboration of stakeholders in projects of public interest. We found that the project clients are not the only actors that determine these levels of participation and collaboration. Sometimes, Stakeholder Integration Champions assume, or are given this responsibility. Yet they are different in nature and they have different priorities, largely determining – through their own perception of attributes - who collaborates and participates. The second question enquired about how the participation and collaboration of stakeholders take into account their legitimacy. Along with identifying the main attributes of stakeholder legitimacies – namely stakeholders' expectations and capacities, including material and financial resources, recognized authority, legal rights and expertise – we highlighted how stakeholder integration champions take into account these legitimacies, keeping in mind that it will always be submitted both to their own subjectivity and to their own legitimacy.

These findings have implications in construction project management. The typology of Stakeholder Integration Champions might help decision-makers identify the possibilities that are available for enhancing participation and collaboration within projects. They also contribute to a better understanding of the role of key players within construction projects of public interest. However, more than providing final answers they open the field for a vast area of research that still remains to be fully explored.

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Integrated project delivery: the designer as integrator

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Abstract

Process innovation related to integrated project delivery is an important topic in the building industry. Studies on process innovation through the use of integrated contracts usually focus on contractors, and particularly on the possibility of forward integration into the building process.

Three years ago, the first author investigated the process innovation capabilities of architectural firms by using the concept of system integration. This led to the idea that architects could take on the leading role in design-build contracts. Based on the results of that study, the conclusion was drawn that architects certainly have opportunities to act as a system integrator in the building process. By broadening their activities, architects can reclaim their central position, in which design and managerial skills can be combined.

As a result of this promising view, a major client (a Dutch school board with a number of schools under its jurisdiction) and an architectural firm decided to develop a new concept. Together with the authors they developed the organisational and juridical aspects of the concept into a designer-led design-build method and implemented it in practice: the design and realisation of school buildings. Two projects were intensively monitored. It turned out that the concept has a lot of advantages for both the client and the architectural firm. This paper describes the specific concept and the results of the two pilot projects, and shows that the recognised advantages are consistent with the literature.

Keywords: Designer-led design-build, integrated contracts, process performance

1. Introduction to integrated project delivery

Since Egan's report on rethinking construction, process innovation has attracted intense interest. Various studies on process innovation show the considerable potential of the concept of integrated project delivery (IPD) (Elvin, 2008; Gann, 2000). Compared with the traditional project organisation in construction, IPD is characterised by a collaborative approach of aligning the incentives and goals of the project team through shared risk and reward, the early involvement of all parties, and a multi-party agreement. The term 'integrated practice' refers to a collection of organisational contract structures that include some degree of integration of the traditional phases of design, construct and maintain (Elvin, 2007).

Since the emergence of the concept, several clients have applied IPD in practice. A number of best practices on the use of IPD are described in an emerging literature on applying the concept (Wamelink, 2007). A few years ago, PSIBouw (National Research Programme on Innovation in Construction) carried out extensive research on IPD in the Netherlands. As a result of this study, several key clients (e.g. the Netherlands Government Buildings Agency and the Netherlands Ministry of Infrastructure and the Environment) decided to move from traditional projects to IPD, especially design-build (DB). Volker (2010) states that in the near future, these key clients will work with these integrated contracts in 80% of their projects.

Within the concept IPD different variants or types exist. In the Dutch construction industry, the most common structures are total engineering and Design-Build (DB) (Vogels et al., 2007). While traditional tendering is characterised by the separation of design and construction activities, DB is a delivery method in which the design and the realisation are put out to tender together. The contractor is thus responsible for both the design and the realisation risks. This can be done on the basis of either functional requirements or a preliminary design (Volker & Klein, 2010). In this method, the executive knowledge of the contractor is entered into the design.

The integration of design and realisation brings considerable benefits to the client. Many traditional legal responsibilities are transferred to the contractor, who coordinates the design and construction process and is largely responsible. Integrated delivery strengthens the project team's understanding of the owner's desired outcomes, thus improving the team's ability to control costs and manage the budget, all of which increase the likelihood that project goals, including schedule, life cycle costs, quality and sustainability, will be achieved. In addition to the benefits to the client, the contractor derives some benefits as well (AIA, 2007).

Frequently mentioned benefits to the contractor are the possibility to negotiate on the price rather than having to participate in competitive bidding, and the improvement of the relationship with subcontractors. The AIA (ibid.) states that:

> The integrated delivery process allows contractors to contribute their expertise in construction techniques early in the design process resulting in improved project quality and financial performance during the construction phase. The contractor's

participation during the design phase provides the opportunity for strong pre-construction planning, more timely and informed understanding of the design, anticipating and resolving design-related issues, visualising construction sequencing prior to construction start, and improving cost control and budget management.

The integrated delivery process allows the designer to benefit from the early contribution of constructors' expertise during the design phase, such as accurate budget estimates to inform design decisions, and the pre-construction resolution of design-related issues, resulting in improved project quality and financial performance.

Although the architect is a member of the joint venture, in most of the current Dutch DB projects, a contractor or professional developer leads the consortium (figure 1).

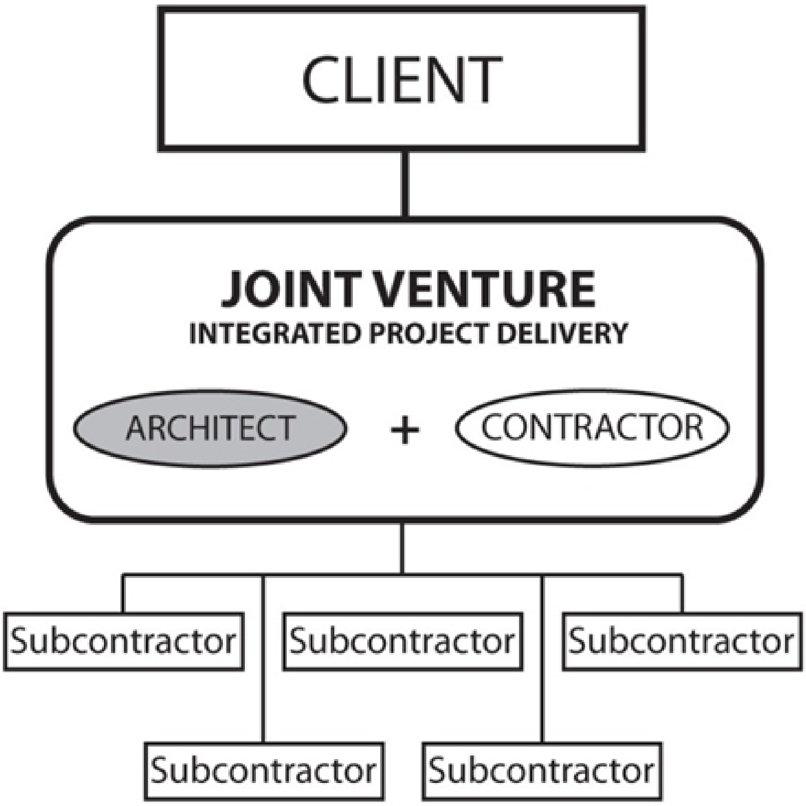

Figure 1: Commonly used design-build organisational structure

Previous studies showed the potential of an integrated project led by the architect or designer (Kornelius & Wamelink, 1998) (Renier & Volker, 2008). It is expected that the typical design competences of an architect really support the process of integration.

2. Designer-led design-build

As mentioned, the leading role in integrated practice in the Netherlands is usually taken by large construction companies. However, various studies show the willingness of architectural firms to play an important role. Volker and Klein (2010) conclude that approximately half of all Dutch architects are interested in developing activities on the market for integrated practices, such as total engineering and DB projects. Volker and Klein (ibid.) state that "although integrated practice has not been the main part of the current portfolio of Dutch architectural firms, it appears that a substantial part of the firms is seriously considering adjusting their organisational strategy for integrated project delivery. It was found that these firms are motivated by the factors that relate to dissatisfaction about the current situation".

The situation is the same in other countries. For example, the Design-Build Institute of America states that only 17% of the DB projects delivered are designer or architect/engineer (AE) led; the vast majority are general contractor led. An often cited reason for this lack of designer-led DB (DLDB) is that architectural firms do not have sufficient financial strength. Most architects want to be involved in a DB as a designer in the consortium contract where the contractor has the final responsibility as contracting party (cf. figure 1). An investigation by Klein (2009) shows that only 3.6% of Dutch architects opt for a DLDB. In this scenario, the architectural firm acts as the party responsible for both design and realisation. The kernel of this approach is that the design profession is responsible for the entire DB process (Quatman, 2003). Figure 2 shows the contractual relations in the case of a DLDB.

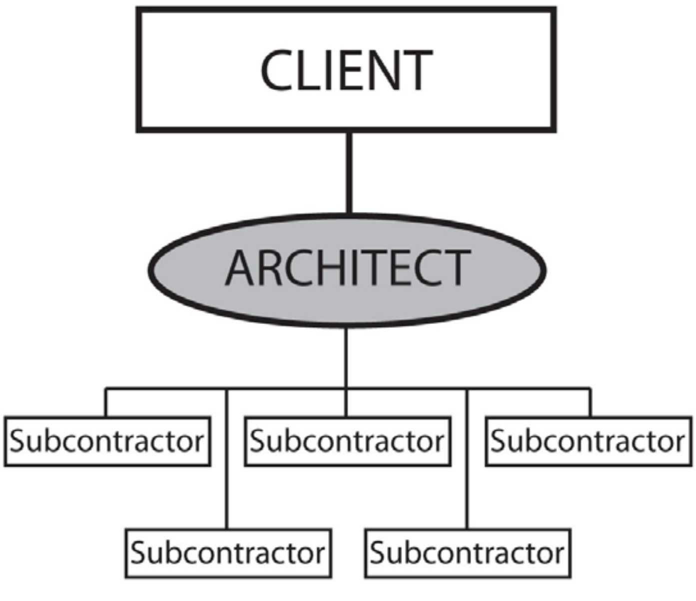

Figure 2: Contractual relations in designer-led design-build

Besides the general advantages of IPD, the supplementary advantages of a DLDB are mainly related to the positioning of the architect at the centre of the process. For example, the architect can guarantee prices related to the quality of the object and can avoid design changes, or even change the design during the realisation phase without having to engage in irrelevant discussions on change orders. Another frequently mentioned advantage is that the architect can manage the original ambitions during the later stages of the project.

The risk management profile of a DLDB is an important issue. It is mainly for this reason that most architectural firms are reluctant to take on such a key coordinating role. They are aware that they have to combine several new competences, such as knowledge of financial issues, onsite working methods and managerial skills. The need to have this combination of new competences means that only a few architectural firms are capable of entering the market of DLDB projects. Since the decrease in the number of projects in the Dutch construction industry, it appears that a substantial number of firms are seriously considering adjusting their organisational strategy for IPD (Klein, 2009). This applies to both the larger and the smaller architectural firms. According to the typology of Coxe (1997), it is thought that strong service architectural firms of some significance have the right competences to join a DB project. This applies both to a contractor-led DB and a DLDB. In the case of a contractor-led DB (figure 1), the architect needs substantive power in order to facilitate his wishes. In the case of a DLDB (figure 2), a considerable size is needed to bear the organisational and financial risks. In the Netherlands, only approximately 10 architectural firms meet these requirements.

Clients also have to get used to the idea of designers leading a DB project. As in a lot of other examples of process innovation in construction, clients play an important role (Egbu, 2008). Clients must be willing to invest in new relationships and a new way of working.

3. Designer-led design-build: a study of two pilot projects

As stated, although DLDB is a promising development, Dutch architectural firms are reluctant to exploit this opportunity. At the moment, only a few architectural firms and clients are experimenting with the development of a DLDB. One of them is ABC Architects PLC (the firm's name has been changed to provide anonymity).

Over the past few years, ABC Architects concluded that the architect's influence on the quality of the end result had declined, and that the architect's role had been reduced to that of a specialist in the design team. The firm also concluded that parts of the design and engineering process were being subcontracted to other parties, such as the engineering departments of contractors. Together with one of their clients (a Dutch school board that has a number of schools under its jurisdiction), the owners of ABC Architects decided to develop a new working method: the *bouwmeestercontract*. This contract is an example of a DLDB according to figure 2. By using the name *bouwmeester*, the client and ABC Architects show that the contract aims to reposition the architect in the centre of the process. Translated into English, *bouwmeestercontract* means 'master builder contract'. In other countries, the term 'master builder' has different meanings. To avoid the chance of misunderstanding, the original Dutch term (BMC) is used in the rest of this paper. ABC Architects PLC selected two pilot projects to test the BMC method in practice. Both pilot projects involved the design and realisation of a school building. The building costs were about 5 and 10 million euros, respectively. The design and realisation of the two buildings were completed in 1.5 and 2 years, respectively.

3.1 The master builder contract

The *bouwmeestercontract* (BMC) is a DLDB contract in which the architectural firm takes full responsibility for the project. The architectural firm is responsible not only for the design quality, but also for the integrated project quality, scheduling and budgets. The architectural firm also accepts a certain proportion of the associated financial risks.

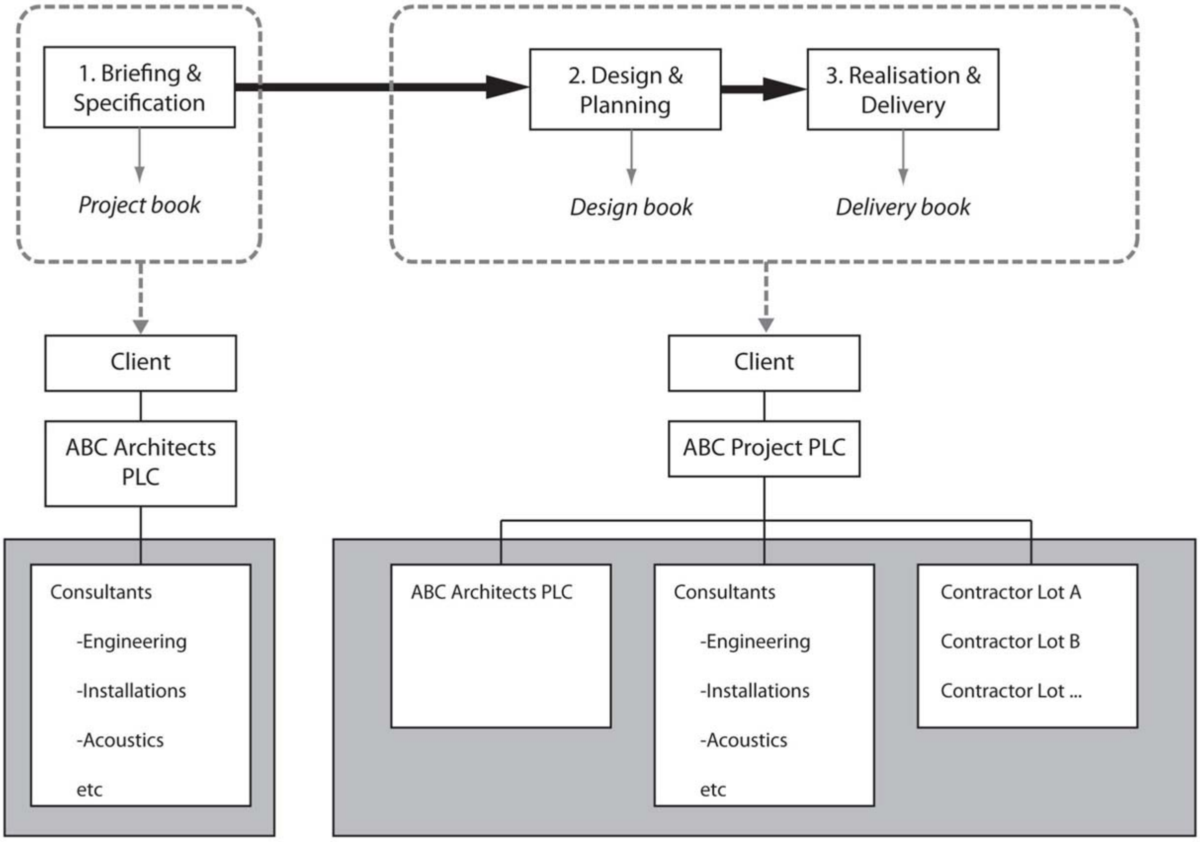

Figure 3 Organisational and contractual structure of the BMC

Figure 3 illustrates the organisational and contractual structure of the BMC. In order to make the DLDB feasible, ABC Architects PLC decided to establish a sister company: ABC Project PLC. As indicated in figure 3, ABC Architects PLC is contract party with the client in the first phase of the project (briefing and specification). In the second and third phases, ABC Project PLC acts as the contract party. The architectural firm is then formally a subcontractor of ABC Project PLC. This distinction is made in order to separate the special risks with respect to the financial aspects and liability during the realisation phase from the firm's on-going business.

The contract was carried out in three phases: briefing & specification, design, and realisation & delivery. Each phase finishes with a specific document (project book, design book and delivery book, respectively). Each time, this document is the starting point for the next phase.

The project book comprises the brief, the sketch design, a budget and a time schedule. The brief is composed of two parts: a part with ‘the basic quality’ and a second part with additional options. The additional options are to be realised in a later phase of the project if no financial setbacks arise.

In the next phase (design), the project book functions as a contract document between the client and ABC Project PLC. The design book includes the architectural and technical elaboration of separate packages from which the project is built. These separate packages are put out to tender separately. After approval of the design book by the client and receiving the necessary permits, the realisation phase starts. After completion, the project will be evaluated and the delivery book finished. Based on the project book, the client and ABC Project PLC establish a ‘project-plus fund’. This is a kind of a reward mechanism, a financial reserve with a pre-determined size (approximately 5% of the total costs). During the project, this fund can be used for several purposes, for example to finance unforeseen costs or to increase the building quality. The size of this project fund changes continuously. Sometimes money is needed from the fund. When special packages are put into market for less costs than estimated, the amount of money in the project fund increases.

The BMC contract brings a shift in roles and responsibilities within the project organisation and in the way they work together. The architectural firm enters as coordinator of the realisation phase and manages all kinds of subcontractors. The architect is responsible not only for the quality, but also for the budget and the schedule. During the realisation, the responsibility for the coordination lies with ABC Project. The daily onsite management on site is outsourced to one of the subcontractors as part of one or more packages.

3.2 Pilot research method

To learn more about the applicability of the BMC, we chose to conduct a qualitative monitoring study, which combines ex-ante and ex-post elements. The objective of the study was to discover the (dis)advantages of the BMC contract and compare them with the common tendering procedures in the Dutch building industry. Conclusions can be drawn whether it makes sense to proceed with the development of the BMC and to initiate more projects with the BMC in the future. It’s self-evident that monitoring these pilot projects doesn’t give conclusive evidence of the BMC’s applicability.

The study started in 2009 and finished at the end of 2011. The selected projects were monitored periodically. This was done on the basis of two interview rounds: during the design phase and at the end of the realisation phase. The first round of interviews was aimed at the expectations of the client and the architect regarding the application of the BMC (the contractors were still unkown). The interviews with delegates of the client and the architect took place separate. After the interviews feedback reports were written and delivered to the respondents. Finally, the findings on expectations were discussed in the steering committee of the project. The second round of interviews was carried out in the same way, but focused on the fulfilment of the aforementioned expectations. Also in this case, the conclusions of the interviews were submitted separately to the respondents and then to the Steering Committee.

It was decided to focus and monitor the following subjects:

- Optimising the price/quality ratio
- Process transparency
- Risk control
- The role of the architect.

The reason to choose these subjects is the expected change compared to the traditional processes.

3.3 Observations

At the end of the study expectations and their fulfilment were compared, leading to the following findings:

Optimising the price/quality ratio

- Both the architect and the clients are quite satisfied with the price/quality ratio. They concluded that a high price/quality ratio was realised. Several design options were realised at significantly lower cost than previously budgeted. This effect was probably partly achieved due to the current climate in the construction market. In one project the difference between the estimate and the realised cost price is so inordinate that the effectiveness of the BMC at this point can be assumed.

- The end users (the schools' management and teachers) are satisfied with the functional, aesthetic and technical quality of the buildings. Some outcomes are a direct result of applying the BMC: they were an additional option in the brief and were funded by the project-plus fund. Beside this, the end users see that the realised quality is a result of the involvement of the architect, the ability to change design during the realisation phase and the division into packages.

- ABC Architects PLC is satisfied with the quality achieved. This applies particularly to the finishing and the installations of the school buildings.

- As a result of their early involvement in the process, most subcontractors saw opportunities to achieve a higher quality for the same price.

Process transparency

- The client experienced the intended financial transparency. The client also experienced much transparency about design considerations. This means that in some cases, the client participated in design decisions.

- The end users also experienced a transparent process. The ability to participate in design discussions with the architect was judged positively.

- The subcontractors concluded that the use of the BMC did not lead to greater transparency.

Risk control

- The risk management methodology should be developed further. During one of the projects risk weren't mapped out properly. Also the allocation of risks to the appropriate project parties led to discussions. In combination with a flexible brief (which distinguished between a basic quality and additional options), windfalls can be used effectively to introduce more quality into the design.

- The serial execution of packages reduced risks related to the time schedule. Both projects were delivered on time.

- The projects also experienced setbacks. In one project, asbestos removal and soil remediation led to considerable upheaval. The transparent process ensured that these risks were more visible to the client.

- The pilot character of the contract itself introduced several new risks. Most striking is the lack of clarity with respect to the relationship between this contract form and European tendering rules.

The role of the architect

- All parties recognise that the architect had a much more dominant role compared to other integrated contracts. Especially the end user and the subcontractors (suppliers/producers) experienced the intense and direct contact with the architect as positive.

- In the eyes of the client, the separation between ABC Architects and ABC Project clouded the principle that the architect is responsible for the project.

- During the realisation phase, the responsibility of the architect was not recognised by all parties. This was reinforced by the fact that the coordination at the construction site was outsourced as part of one or more packages.

3.4 Conclusions

Returning to the objective of the pilot study, it can be concluded that in particular the client and architect are satisfied with the results. They are satisfied with the achieved quality. The quantifiable result is positive, and the quality was realised at costs lower than the initial budgets. The client and some of the contractors experienced the process as highly transparent, and all parties recognise the guiding role of the architect in these projects. The client, end users and subcontractors were most positive about this role. They experienced the direct contact with the architect as an important source of the realisation of quality, and appreciate that they also had a lot of ownership in the project. The party that usually operates as a main contractor in traditional projects was less enthusiastic. This follows from the fact that his role in a BMC project is considerably smaller than usual.

Despite the fact that this study doesn't give proof of the applicability of the BMC in other situations, the conclusion is justified that there are good reasons to develop the BMC concept and apply it in new projects. The legal aspects (including the application under the European tendering rules), risk management and coordination procedures should be developed further. Since the BMC is a very specific application of a designer led design built contract, the results of the pilot study are also interesting for other countries

4. Discussion

Thus, the BMC leads to advantages for integrated project delivery in general and for designer-led design-build in particular. The effect of repositioning the architect as a coordinator works on many levels in the process. This study confirms the recommendations with respect to the use of DLDB, such as those concerning essential principals and business models from the AIA (2007). Examples of these principles are the concern for mutual respect, mutual benefit and enhanced communication. The AIA states that "in an integrated project, client, architect, consultants, contractor, subcontractors and suppliers understand the value of collaboration and are committed to working as a team in the best interests of the project. Because the integrated process assumes early involvement by more parties, the compensation structure must recognise and reward early involvement. Compensation should be based on the valued added by an organisation and risk should be equitably allocated. Focus on team performance is based on communication among all participants that is open, straight and honest. Responsibilities are clearly defined in a no-blame culture leading to identification and resolution of problems, not determination of liability". The present study confirms these general principles.

The positive experiences with a DLDB described in this paper should be a key reason for Dutch clients and architectural firms to continue along this path. As mentioned in section 2, about 50% of Dutch architects are interested in participating in DB projects. The Dutch association of architects could foster the idea, collect best practices and develop tools and methods. Finally, the sector needs to incorporate such other developments as building information modelling, which will strengthen the advantages of integrated project delivery.

5. Acknowledgements

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Construction and design issues for construction manager/general contractor highway projects

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Abstract

Fast-tracked construction projects are nothing new. The use, however, of some types of fast-track contracts in certain sectors of the construction industry is new. One example of this is the use of Construction-Manager-at-Risk (CMR) within the highway construction industry in the U.S. Even newer is the similar concept of Construction-Manager-as-General-Contractor (CMGC). The traditional system of design-bid-build (DBB) has been employed by all Departments of Transportation (DOT) in the U.S. for almost a century. The shift toward design-build (DB) as a time-saving method has been successful in many ways, but use of the system during the past decade has revealed some disadvantages. CMR is a delivery system often employed in vertical construction, and transportation agencies have recently begun to use it for horizontal construction. CMGC cannot legally be used for public transportation construction projects in most U.S. states, but once an agency has decided to pursue the implementation of CMGC, there are certain broad concepts that must be understood. In many cases, this requires a significant and aggressive change in the culture and philosophies of the constructors and designers from traditional DBB design projects. Designers are required to take a much more active role in working with the owner and constructor during the entire design process, for such things as early and continuous value engineering, right-of-way phasing, real-time pricing, increased coordination meetings, accelerated designs, etc., during the early stages as well as throughout the entire design process. Designers may therefore need to be educated in the process of receiving real-time input from the constructor, as well as being flexible in modifying standard items such as traffic control plans, to best fit the chosen approach to construction.

Keywords: Construction-Manager-at-Risk, Construction Manager/General Contractor, Design Process

1. Introduction

All construction once was performed using a form of the design-build (DB) delivery system. In the 1920s and 1930s, knowledge of construction materials and methods grew at a rapid pace due to significant research, mostly sponsored by the American Association of State Highway Officials, now known as the American Association of State Highway and Transportation Officials (AASHTO). With this new knowledge came specialization, and with specialization came the design-bid-build (DBB) project delivery system, which dominated horizontal construction in the U.S. for decades. The monopoly of this traditional system lasted until the Transportation Equity Act was enacted. In 1998, it became much easier to procure federal funding for projects utilizing alternative delivery systems if the use of those delivery systems was in compliance with the states' own contract procurement statutes. Due to the success of numerous DB projects, the states have become increasingly receptive to these new concepts of project delivery. Now many states allow application of alternative delivery methods to public transportation construction projects, but some states differentiate their processes of authorization for DB and other alternative delivery systems such as construction-manager-at-risk (CMR). In recent years, a new delivery system similar to CMR, called Construction-Manager-as-General-Contractor (CMGC), has been introduced to highway construction. Early indications are that contractor organizations prefer CMGC to CMR.

1.1 Design Bid Build

The traditional procurement system for highway construction involving the separation of design and construction services, the qualifications-based procurement of designers, and the competitive low-bid system for construction has served the public well over the past century. The foundation of this system, often called Design-Bid-Build (DBB), is the principle of selecting designers based on qualifications and selecting construction contractors based on competitive sealed bids, with award to the lowest responsive and responsible bidder. State statutes governing highway construction often require agencies to award contracts to the lowest responsible bidder, based on 100% Plans Specifications & Estimates (PS&E) (Scott *et al* 2006).

Over the decades, DBB has provided taxpayers with an adequate, safe, and efficient transportation facility at the lowest price that responsible, competitive bidders can offer. However, this process can foster adversarial relationships among the project parties, limit innovation, result in high cost and time growth, and may not necessarily provide the best-value to the owner for all project circumstances or types.

1.2 Construction Manager / General Contractor

Concerns held by owners about the lack of control of the design process in a DB contract, and a plethora of problems with DBB have caused some transportation agencies to seek alternatives to DBB and DB for project delivery. A promising alternative that has generated interest in the highway sector, CMR, modified to CMGC, may offer some of the same advantages as DB related to expediting delivery of projects while allowing the agency to retain control of design through a separate contract with the designer.

CMGC is an integrated team approach that applies professional management during the planning, design and construction of a project. The team consists of the owner, the architect/engineer, the construction manager (CM), and subcontractors. As in the case of DBB, the owner contracts separately for design and construction services. However, the CM may be retained about the same time as the architect/engineer typically using a qualifications-based selection process.

During pre-construction, the CM acts as an advisor, providing professional services to the owner. A CM will perform constructability reviews, cost estimates and budget recommendations to assist in determining the best options for the owner based on the project budget and also may perform duties not typically performed by contractors, such as assisting in securing financing, or selecting or helping in the selection of design.

When the CM is “at risk,” it becomes the General Contractor (GC) during the construction phase. The CMGC awards subcontracts in either a fixed-price, cost reimbursable, or guaranteed maximum price (GMP) contract. In addition to acting in the owner's interest, the construction manager must manage and control construction costs to not exceed the GMP.

2. Literature Review

2.1 Horizontal Projects

The National Cooperative Highway Research Program (NCHRP) has funded many comprehensive studies regarding project delivery in horizontal construction. In this field, the two most commonly employed methods of delivery are DBB and DB. Gransberg (1999) conducted a survey of 15 DOTs; the results showed DB to be the alternative method commissioned by all DOTs. Through further analysis, Gransberg was able to identify three different systems that were used to advertise and award DB. Low-bid, adjusted score and best value were then compared to identify their strengths and weaknesses.

Scott (2006) pointed out the problem associated with low bid in DB; instead of getting the benefits of cost control, most of the time it will result in a decrease in the quality of the final product. Scott focused on the best value approach, which places the emphasis not only on the price but also on other factors.

Shr (2004) studied the growing popularity of incentive/disincentive bidding for highway construction. This method was found to shorten the contract time by making it difficult for the contractor to not accelerate the project.

2.2 Design-Build

Molenaar et al (1999) studied the emergence of DB into the public segment of the industry, replacing traditional DBB. His work analyzed each party’s responsibility with regard to the delivery system and also explains the procurement process and the structure of this particular method. Marwa et al (2006) went more in depth than Molenaar. Marwa studied a total of 76 DB projects in his research and identified correlations between the procurement processes and the projects' overall performance. Chan (2002), in his research, sought specific project conditions that could help increase success rates of projects when using DB. Chan points out that measures of success are defined by three factors—time, cost, and quality—but he believes that a more comprehensive metric should be established.

Gransberg (2008) addressed the issue of quality assurance concerning DB as it relates to transportation projects. One of the disadvantages of DB is the lack of control over the detailed components of construction, which requires the agency to form a more comprehensive method to ensure the quality of the work. A survey from the report demonstrated the different ways in which state transportation agencies have successfully controlled quality by focusing on all aspects of the construction phases; but this does not seem to be the case for all agencies.

2.3 CMR / CMGC

The ability to shift the risk involved with construction has made CMR one of the leading delivery methods in vertical construction. A nationwide CMR survey (2009) conducted by Associated General Contractors of America (AGC) and National Association of State Facilities Administrators (NASFA) shows the popularity CMR has obtained. Of the fifty states, only Michigan and Indiana were prohibited from using CMR on state or federally funded vertical projects. The key principle of this delivery system is the ability to transfer risk, which was explained by Strang (2002). Strang was able to define CMR from the owners' point of view and discuss all the issues of which CMs should be aware. Strang compared the building and CM to a "product" and a "vendor." He further explained that "of all the risks that manufacturers and operating companies experience in other lines of work, hidden defects can come back to cost dearly years later."

Due to the fact that CMR is rarely used in horizontal construction in many states, the amount of experience with CMR among many members of the horizontal construction industry is minimal. But Gransberg (2009) did conduct extensive research on CMR project delivery for highway programs. This research provides information on the process of how the system should be used, case studies of CMR projects, and statistics of CMR usage from all state DOTs. The report shows that Utah DOT (UDOT) has the most experience with the CMR (CMGC) method. It has completed 13 CMGC projects, and 16 current projects will be completed with CMGC. UDOT confirms the system's ability to fast-track projects, which can result in decreased project cost. Other states such as Alaska, Arizona, Florida, and Oregon also have experience with CMR as a method of delivery on transportation projects. The city of Phoenix, Arizona, has had more than 200 projects completed using CMR (including both vertical and horizontal projects). Local transportation projects in Michigan and Rhode Island also used the CMR delivery system.

2.4 Methods of Choosing the Appropriate System

Comparison among DBB, DB, and CMGC has been an area of focus ever since the emergence of alternative delivery systems as an option. Significant funding has been invested in studies to help understand the characteristics of each system, especially with regard to cost, time and quality. Ibbs (2003) used sample case studies to confirm one of the key advantages of DB. DB does in fact perform more efficiently with respect to time than traditional DBB. Doren (2005) discovered valuable statistics regarding CMR. In that study, 35 percent of project owners believed that CMR provided them with the “best value,” followed by 23 percent for DB; yet the traditional system of delivery (DBB) is employed most frequently. Doren’s research combines data from the areas of vertical construction and horizontal construction. According to him, government agencies that have experience with an alternative method consider CMR and DB as the “best-value alternatives.” Doren believes that CMR has the potential to become the leading method of delivery, due to positive experiences reported by so many agencies.

Rojas and Kell (2008) used data collected from different states to compare the performance of DB and CMR in projects involving public schools. The result of the study conflicted with much previous research by concluding that 75% of the cases exceeded the guaranteed maximum price (GMP) when CMR was used. However, these statistics were gathered from vertical projects, which are fundamentally different from horizontal projects.

3. Research Methodology

This paper describes the results to date of two research projects, one completed project into the construction aspects of CMGC and one ongoing project into the design aspects of CMGC. Therefore, the Research Methodologies of both will be given here.

3.1 Construction Aspects

3.1.1 Description of Study Population

The research sponsor designated eleven states from the southeastern U.S. as the area of interest. A list of state construction personnel was gathered from the AASHTO Subcommittee on Construction Management. These names served as the potential interviewees. As the research was carried out, some of the personnel contacted did not have suitable knowledge of alternative delivery systems employed in their DOTs. In such cases, recommendations were taken on the appropriate source of information. Most personnel interviewed were state construction engineers for their respective DOTs.

3.1.2 Development of Interview Instruments

Two levels of interview instruments were created for this research. The purpose of the first-level instrument is to determine the agency’s exposure to all three delivery systems and to explore the organization’s preference between the current systems of employment (DBB or DB). The issue of regulation regarding alternative delivery systems is also addressed in this instrument. The second-level instrument is an extensive study of how the agencies utilize the CMR method of delivery. In the study, the focus was placed on the specific performance of CMR compared to DBB and DB. These specifics included the responsibilities and risks involved with crucial parties of DB and CMR, as well as the financial aspect of the project as it relates to the method of compensation and contingencies. The interview instruments are role specific and include four different versions.

3.1.3 Procedure for Interviews

The first-level questionnaire is compact in nature. Since it covers agencies spread over a large part of the country, it was conducted over the telephone. The second level requires more time in comparison to the first, so phone interviews were scheduled at times that were convenient to the interviewees. When possible, face-to-face interviews were conducted; in these cases, only one interviewee was engaged at a time in order to limit bias in responses.

3.1.4 Analysis of Data

After the interviews were completed, analysis of the interviews was conducted. The goal of this step was to draw any correlations in experience among all DOTs, compare the usage of the three systems, and identify any strengths and shortcomings each method may have. This study revealed the number of years each DOT has been exposed to DB and CMR methodology. The performance of the systems was analyzed and compared, especially in respect to the points of view of the construction managers, designers, owners, and subcontractors/suppliers. Finally, an overall comparison of all participants' experiences was conducted.

3.2 Design Aspects

Only portions of this research have been completed as of this writing, but the entire research plan will be shared here.

Task 1.
Review recent experience of DOTs and other public agencies regarding design management practices used on projects under CMGC.

The agencies that have the most experience will be identified in Level 1and asked to participate in Level 2 of this interview process. Those agencies participating in Level 2 will take part in a second telephone interview and will be sent additional questions by e-mail or via a research project website. Level 2 participants will also be asked to provide answers to more in-depth questions, as well as data from their projects and documents. From the in-depth questions, critical assessments will be made regarding the relative merits of alternative approaches of managing key aspects of the design that affect project scope, quality and cost. Several questions to the participants will include dealing with lessons learned from design management under CMGC and DB that may be effectively applied under other project delivery methods. Common practices such as discipline in the scoping process over the life of a project have value regardless of the delivery method utilized. Issues related to liability and responsibility within the design process will also be explored.

The results of these Level 1 and Level 2 surveys will help guide the selection of case study projects. It is from these Case Studies that the most in-depth data will be gathered. Agencies whose case studies will be explored further will be visited by one or two team members to conduct detailed interviews and gather more specific information for inclusion in the other research products of this project.

Task 2

Based on experience reviewed in Task 1, develop a framework characterizing principle areas where owners' design management practices under CMGC project delivery processes are likely to influence project success.

Based on the information gathered in Task 1 the team will construct the framework that will allow owners to characterize their practices under CMGC. This characterization is important because it will provide an agency with the format and criteria against which to gauge their current practices against attributes of those agencies who are successful in the area of interest. Among the principle areas to be included in the framework are the following:

- Agency commitment including executive and middle management leadership
- Agency culture (collaborative)
- Established project goals and objectives
- Adequacy of owner capabilities to manage cost, budget, risk, and project management
- Means for managing risk, cost, scope, and schedule
- Existence of communication channels
- Engagement of designers and constructors
- Methods for ensuring design quality
- Statutory conditions (e.g. limited or broad)
- Agency culture (beyond collaboration)—focusing on the level of risk adverseness
- Industry collaboration and support

Task 3

Develop templates for describing owners' expectations for how design QA and QC are to be ensured throughout design development under CMGC project delivery.

For a template to be valid and useful it must have a measure of universality and scalability such that it can be applied to projects of all sizes. The experience of the team members indicates that it is just as, or more, important for deliberate and disciplined management practices to be in place on smaller projects than on larger endeavors. The template will have some basic elements such as designer scope, roles and responsibilities and project delivery method. From these a particular project may take a number of paths to completion. For example, in a DB effort the designer will be a member of the design-builder's team. Basis of payment under this circumstance will be different than on a CMGC project where the design services are procured through the owner. Thus, the template must recognize these differences.

An important element of the template is the owner's role in decision-making during the course of the project. This varies between methodologies. Ironically, even though it varies, agency culture, management philosophy and decision-making discipline are important regardless of the delivery method. In fact, they may be more important than some of the other attributes of the design process.

Task 4

Using the materials prepared in preceding tasks, prepare the Guide for state DOTs and other transportation agencies on design management under CMGC project delivery.

Based on the information gathered and developed to date the team will prepare the guide for the state DOTs and other transportation agencies who will benefit from greater knowledge and application using the CMGC methodology.

4. Results

Even though all interviewees expressed awareness of the existence of the CMR and CMGC delivery systems, only Florida has hands-on experience with it as a tool for highway construction. In fact, CMR has been authorized in many states to help offer a possibility other than DB as the alternative delivery method. It is designed to help decrease the amount of oversight that normally takes place on construction projects, and it reduces the amount of performance risk for the owner and transfers it to the CM. A constructability review by the CM becomes part of the design phase of the projects. This, along with a direct contractual relationship between the owner and the designer, allows the agency to remain in control of the design process. Of course, this method still offers the advantage of fast tracking the project.

Since Florida is the only state in the study to utilize CMR for highway construction, FDOT was the only DOT to participate in a Level Two interview. Ten FDOT projects have been commenced using CMR. In addition to the list of projects and the state's statute, the interviewees were able to provide more in-depth assessment of CMR by submitting to the Level Two interview. To gain information on CMR, the team decided to compare the performance of CMR to DB as well as to DBB. It is well known that all DOTs use DBB more than any other delivery system, so no questions were asked regarding DBB except how it compared to CMR in some way. The questions began with inquiries regarding DB. Table 1 shows how FDOT views the risk/responsibility distribution for DB and CMR.

Table1. FDOT's Risk/responsibility Distribution for DB and CMR.

Risk/ Responsibility	Design-Build Project		Construction-Manager-at-Risk Project		
	Owner	Design/Builder	Owner	C.M.	Designer
Final Alignment Geometry		X		X	
Geotechnical Data	Depends			X	
Environmental Permits	X		X		
Design Criteria	X		X		
Design Defects		X		X	X
Constructability of Design	X			X	
Obtaining ROW	X		X		
Coordinating With Utilities/Railroads	Depends			X	

Quality Control		X		X
Quality Assurance	X		X	
Acceptance		X		X

The main reason FDOT decided to employ CMR was its ability to shift risk and fast track while allowing the department to retain control of the design process. FDOT plans to continue using CMR on horizontal projects because of this unique characteristic. But not all projects are suitable for CMR. The following are some of the project traits that FDOT uses to help them decide whether or not to use CMR (FDOT 2012):

- Building type projects where construction methods and specifications vary between professional groups (i.e., engineer/architect and construction trades).
- Innovative funding scenarios, where multiple owners may dictate final project criteria.
- Projects where limiting (limited) budgets (budget) threaten (threatens) the delivery of the project and where the CM alternative can help maintain costs.
- Other projects where construction input is required during the early phases of design.

FDOT has used CMR on a variety of projects. The majority of projects could be categorized as "combination" projects due to the fact that they contain work in both vertical and horizontal construction areas. In fact, six of the 10 projects are of this variety. These six combination projects include an Interstate Highway Agricultural Station, three Interstate Rest Areas, an Interstate Welcome Center, and the massive MIC. There are two vertical construction projects—an FDOT office building and a building at an Interstate Highway Agricultural Station—which are located on different Interstate highways than the one mentioned above. Finally, two are solely horizontal construction projects, both of which are bascule bridges.

FDOT's CMR project costs ranged from $3.2 million to $78 million, based on accepted GMP. The $78 million project is the MIC rental car facility, which will surely grow based on decisions for further GMPs. The entire MIC is not being built using CMR. Of the eight projects that have had an engineer's (preliminary) estimate and an awarded GMP, six have been awarded for GMPs above the engineer's estimate and two for GMPs below the engineer's estimate. Of the two FDOT projects that have reached the final estimate stage, one was completed under the GMP and one was significantly over the GMP. Both completed projects exceeded the original duration slightly (less than two percent). Due to the sample size of completed CMR projects, statistical analysis was not conducted.

Many people felt like they were more a part of a team when under a CMR contract, compared to when working under a DB or DBB contract. Several said that "everyone is working toward the same goal. Most agreed that the proper time to bring the CM onto the team is at the 30% plans milestone, though some said earlier and some said later. Several noted that CMR made using DBEs easier and increased local contractor participation. Approximately 80% said that CMR requires less manpower than the two alternatives. Several said that high quality was easier to achieve using CMR than with DB or DBB because no one is tied to a low-bid scenario and the best people can be chosen to work on the project. When discussing how Requests for Information (RFI) are different, many said that the difference is not the way an RFI is processed, but in why it is processed, that an RFI on a CMR project is an honest request for information, while an RFI on a DB or DBB project is the first step in making a case for a claim.

4.1 Case Study: Osceola County, Florida

In both research projects, once the initial interviews had determined the most interesting and relevant programs for CMGC, researchers travelled to the program locations and conducted in-depth, on-site research that resulted in several case studies. The Osceola County, Florida program was chosen as a Case Study on both the construction and design research projects.

When authors Ken Atkins and Gregg Hostetler became the Public Works Administrator and the Deputy Administrator they became major players on a newly appointed team that was faced with a unique and daunting challenge. Three previous County Administrations, along with associated staff, had been removed by the Board of County Commissioners for failing to deliver an extremely aggressive impact-fee-funded roadway program, totaling approximately $1.0 billion. The Program required that nine to eleven major roadway projects be under construction within a year, with an additional seven being completed in design, each calendar year. Since its enactment, the impact fee had been assessing extremely high impact fees (some of the highest in the nation) thereby negatively affecting development, with very few constructed roadways to show for it. Based on the original requirements, the County was eighteen projects behind schedule, totaling over four hundred million dollars in design and construction when the authors took over. Less than seven years into the Program, there were five million dollars in unaccounted for change orders. Designs were as much as two hundred percent over budget, in some cases remaining at the thirty percent design phase for over eight years. One project had taken eighteen years to go from start of design to completion of construction. Lack of solid leadership by the County staff and administration resulted in eighteen different projects being at various stages of design, with none of them being truly construction ready. Consultants, both design and construction, were extremely frustrated by the lack of clear direction from County staff, as well as by the numerous inconsistent and costly changes. Initially, when looking into CMR, very few design firms were strong advocates for using the system for such a large program, i.e. eighteen major roadways. In their opinion the County did not need to add yet another layer of management to an already overburdened, costly, slow, and extremely bureaucratic system.

In addition, they believed that CMR was an unproven method for roadway construction and that the outcome would potentially be catastrophic. Many design firms believed that the constructability reviews (proposed to be conducted by the CMR firms) overlapped the constructability reviews being paid for under the existing design contracts. Several of the firms had existing Program Management contracts with the County, which they believed performed the same services as a CMR firm.

Another concern was that involving a CMR firm, at such a late point in the design stage, would increase the design budgets, which were already spent in many cases. They also believed that coordinating with the CMR firms would be very costly in time which they could not afford to lose in such a challenged market. These were all valid concerns from the viewpoint of those holding them, but did not prove to be accurate.

In order to begin this Program a tremendous training effort was initiated, focused on the Design Community. Eleven advantages of CMR were explained to the designers involved in the Program. The top three are listed here:

1) Enables the designer to work daily /weekly with the CM to review designs as they were conceived and drawn, versus at 30, 60, and 90% plans stages, for constructability, budget, and value engineering.
2) Allows the designers to adjust their plans using "real time" information versus waiting for a project to be bid or an estimator to review the plans in their entirety.
3) Removes the requirement to have 100% signed and sealed drawings to bid the work. Plans only needed to be at a level of completion that allowed contractors to estimate the work. The designs were all still taken to 100% signed and sealed drawings after reviews and estimates were completed.

Just as was the case with the design firms, initially the majority of Project Management firms (for both design and construction) were not convinced that using CMR for roadways would work. Many of these firms currently performed what they classified as design and construction management and therefore strongly believed that there was a definite conflict between what they already provided and what the CMR was going to provide. In reality, this was not the case. In order to begin this program a training effort similar to the one aimed at the design community was initiated with the Project Management community. Seven advantages were explained to the Project Managers involved in the program. The top three are listed here:

1) Enables the County to significantly reduce the positions related to internal oversight of the private design firms, thereby potentially reducing up to 40% of the internal overhead.
2) Eliminates Program Management Contracts, potentially saving millions of dollars over the life of the impact fee ordinance.
3) Assigns two Project Managers to each project (one for design and one for construction) thereby significantly reducing staff positions and legacy costs. Once the projects were completed, these Project Managers would return to the firms. This allowed for program ramp up during busy times and program ramp down during slow times.

Fortunately, the Team's Program was extremely successful and has been highlighted as the most rapidly deployed, innovative, successful, and largest roadway construction program in the nation, to date, using CMR as its sole delivery method. The tremendous results of the Program can be seen in the literature (ENR 2010).

5. Conclusions

Overall, 79% of those interviewed in the survey prefer working on a CMR project over a DBB or a DB project. Half the interviewees at the Cape Coral location did not have any preference regarding this issue; this is mainly due to their limited experience with other delivery systems. Most of the participants favor the CMR method because of its ability to facilitate communication flow, minimize the adversarial relationships between the parties, and reduce the amount of stress that is associated with the process. With the CMR method of delivery, numerous interviewees reported experiencing more of a team atmosphere.

Most of those interviewed preferred CMR to DB or DBB. A theme that was heard repeatedly in all the interview locations was that people felt like they were more a part of a team when under a CMR contract. Many alluded to the fact that “everyone is working toward the same goal. Most interviewees asserted that the proper time to bring the CM onto the team is at the 30% plans milestone, though some said earlier and some said later. Several of those interviewed said that using CMR made the use of DBEs easier and increased local contractor participation. Approximately 80% of those questioned said that CMR requires less manpower than DB or DBB. Several interviewees said that it was easier to achieve high quality using CMR than with DB or DBB because at no time is anyone tied to a low-bid scenario and the best people can be chosen to work on the project. When discussing how Requests for Information (RFI) are handled, many said that the difference is not in the process by which an RFI is processed, but in why it is processed. They contend that an RFI on a CMR project is an honest request for information, while an RFI on a DB or DBB project is the first step in making a case for a claim.

A Case Study was summarized for a group of people successfully implementing CMR as the only delivery system for a $1.0 billion construction program in Osceola County. The new administration made many bold and innovative decisions, but the key to the success of the program seemed to be communication and training. The new administrators undertook a massive effort to educate stakeholders as to the advantages that CMR offered for them. The approach to the construction consulting community and the design consulting community were detailed.

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ICT initiatives in primary education: a built environment research challenge

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Abstract

The last decade has seen an array of ICT initiatives in education aiming at decreasing inequality and digital exclusion. The One Laptop per Child (OLPC) project provides children in developing countries with Internet connected laptops free of charge. As part of this project, Uruguay is the first country to provide every public primary school child with a laptop through the Plan Ceibal. The Plan represents a major investment to promote digital literacy and improve the quality of education. However, several conflicts arise when new technologies are introduced into the educational system. Amongst these is how the introduction of new tools and changes in pedagogical approaches conflict with existing school facilities. There is little current knowledge about what an integrated approach to operating, maintaining, improving and adapting the school buildings and infrastructure in order to create a supporting environment might look like. This paper reports on a research project initiated to explore and unravel the tensions that the introduction of laptops pose, and establish the different ways in which these can be alleviated. Empirical data is drawn from an ongoing multiple case study of five public primary schools. Particular attention is given to how school facilities and their immediate surroundings mediate the successful introduction and adoption of individual laptops. We argue for a context sensitive view on research that not only considers potential changes in pedagogical approaches, but also the physical environments in which these changes are supposed to take place.

Keywords: digital inclusion, educational facilities, ICT, learning environments, innovation.

1. Introduction

Inequality in the use and application of digital technologies within and amongst countries has become a driver of exclusion, which risks accelerating existing social divides and creating new ones (cf. Cardellino and Leiringer, 2010). Moves to incorporate ICTs into primary education are an important step to battle inequality and digital exclusion. In developing countries, the One Laptop per Child (OLPC) project provides children with Internet connected laptops free of charge. To this end similar developments are emerging all over the world, with initiatives formed to increase the use of personal laptops amongst the youngest of pupils. Regardless of socio-economic status of the country in question these initiatives commonly share the same fundamental aims of improving the quality of education through the introduction of ICT tools (laptops); and promoting digital literacy amongst pupils in primary education. This has generated much research into the specific technology, as well as into the pedagogical approaches that go with it. We argue here that such studies should be complemented with research that allows for a more holistic view of the learning environment. We further argue that construction management research is well placed to contribute.

This paper draws on a multinational research project that aims to study and inform the need for, and use of, individual laptops in primary education, with particular attention given to the role of the physical learning environment. In particular the research focuses on the provision of laptops to all public primary school pupils in Uruguay – Plan Ceibal - an ambitious initiative that so far is unrivalled in the world. The paper takes as its point of departure the realisation that several conflicts arise when new technologies are introduced into the educational system. Not least amongst these is how the introduction of new tools and changes in pedagogical approaches conflict with existing school facilities. Initially a brief description of Plan Ceibal is provided, highlighting the very ambitious and far reaching objectives of the programme. Attention is then turned to the many challenges that an initiative of this kind faces; looking more closely at the barriers to successful uptake. An argument is put forward that positive outcomes are more likely if the changes are compliant with the context into which they are introduced and what previously might have been an adequate learning environment may no longer be so. It follows that research efforts should further explore how the physical environment can support or impede the introduction of laptops and associated pedagogical ideas in forming effective learning environments. This we argue necessitates a shift in cognitive gears, and would to some extent force a change in the range of theories and methods applied. This last point is illustrated through looking more closely at innovation theory and how a shift from the dominant 'economic' view on innovation diffusion to a more contextualised approach is necessary in order to combine this line of diffusion research with the vast amount of work that has been undertaken in the realm of education. Examples from the emerging findings of a multiple case study are drawn upon to illustrate and accentuate some of the points made. The paper concludes by highlighting the important role school facilities play as catalysts for the successful implementation of ICT initiatives in education; and a case is made for broadening the line of research undertaken to also include the design, construction and through-life management of the school buildings.

2. Plan Ceibal

Despite relatively high attendance rates amongst pupils and social and income distribution indicators being among the highest in Latin America, Uruguay was in 2007 one of the countries in the region with the highest level of inequality in learning (OECD, 2007).‘Conectividad Educativa de Informática Básica para el Aprendizaje en Línea’ [Basic Educational Connectivity for Online Learning], or ‘Plan Ceibal’ as it has become known, was developed to address this inequality. The programme was launched by the Uruguayan government in April 2007, with the intention of providing, free of charge, one portable computer to each child and teacher in public primary education. At this time 43% of primary schools in Uruguay had no computer equipment available to pupils; 43% had between one and four computers, and only 14% had five or more (Grupo Radar, 2010). This reflected the situation in society in general where approximately 30% of Uruguayan households had a computer and only half of these had Internet access (Vazquez, 2009).

Recent statistics on Plan Ceibal show that close to 380 000 XO laptops have been distributed to pupils and teachers in 2144 public primary schools around the country (Baez and Rabajoli, 2010). These schools have also been provided with the servers and accompanying routers necessary for internet connectivity. It is also worth noting that since October 2010 another 100000 XOs have been distributed to 1st and 2nd year secondary schools and technical schools. The pupils who have received a laptop have signed a contract guaranteeing that they finish at least 3rd grade.

The specific objectives set for Plan Ceibal by the Uruguayan Education Commission (Comisión de Educación, 2007) focus on the provision and use of the technology. However, it is clearly recognised that the mere introduction of the laptops in schools is not enough to ensure the aspired to changes. Hence, emphasis is also given to the need for appropriate training programmes for those involved and a push for the introduction of teaching and learning approaches that is in line with the new requirements. Accordingly the distribution of laptops has over time increasingly been complemented with the provision of additional resources and training for those involved.

The incorporation of the XOs into the day-to-day practices in the schools has, according to the programme's own records, been partially successful. Some commentators point towards evidence of changes in peer communication among the children, going beyond the use of technology (Balaguer, 2010). However, to date there is only sporadic non-systematic evidence of the positive impacts of Plan Ceibal and its effects on enrolment, attendance, motivation and graduation rates. This is perhaps not all that surprising given that experiences from elsewhere show that several conflicts arise when new technologies are introduced into the educational system (cf. Hinostroza et al., 2004). Not least amongst these is how the introduction of new technologies and changes in pedagogical approaches conflict with existing school facilities.

3. The research challenge

Academic studies in the field of ICT in education are by no means a new phenomenon and the last ten years have seen a vast array of research in this domain with hugely varying findings. In summary, it is evident from the large literature on the topic that new digital technologies have the potential to revolutionise learning, yet it is equally clear that they certainly do not guarantee it. Experience shows that change initiatives imposed on the schools and teachers all too often are used to reinforce existing approaches to learning rather than bringing about change. Most teachers tend to use ICTs mainly to complement, rather than change, existing pedagogical practice (cf. Smeets, 2005). It follows, therefore, that to take full advantage of new laptops there is a need to rethink traditional approaches to teaching and, perhaps more importantly, what constitutes an effective learning environment. Put slightly differently, in order to have a longer lasting effect and to be effectively infused into the school's culture an ICT policy should be designed so that it becomes part of a more comprehensive effort towards improving the equality and quality of the educational environment as a whole. A clear case can thus be made for the importance of adapting not only the pedagogical approaches, but also the physical environments in which they are delivered. This calls for a degree of creativity in research and depends on breaking with the common sense assumptions, looking at the world through a different lens and returning to professional communities with new insights. This is what theory – and by extension, research - at its best can and should provide.

If the view taken of construction extends beyond on-site production to include the entire range of construction services provided by the AEC sector, including design, procurement and through-life management, then this is clearly a domain to which construction management researchers can potentially contribute. There is little current knowledge about what an integrated approach to operating, maintaining, improving and adapting the school buildings and infrastructure in order to create a supporting environment might look like. The research challenge, therefore, is to explore and unravel the tensions that the introduction of laptops pose and establish the different ways in which these can be alleviated. This entails broadening our theoretical positioning to make use of well-established theories from the social sciences as well as drawing on the vast experience and expertise that exists within the built environment research community. It also entails broadening our approach to empirical research in order to further our understanding of how the introduction of laptops changes behaviour in classrooms and the wider school environment; how individual behaviour is shaped by existing facilities; and how the use and upkeep of the facilities can be altered to respond to the necessary changes in teaching and learning approaches. Such a shift in cognitive gears and methodological approaches are necessary if the research community is to offer valuable new knowledge to those involved in the role out of Plan Ceibal.

4. Meeting the challenge

Meeting the challenge depicted above requires research that moves beyond single disciplines and dominant research paradigms. To put these challenges into perspective, the following section reviews and depicts dominant and alternative takes on innovation theory and moves the discussion towards the links between the physical environment and behaviour, motivation, learning and achievement.

4.1 Innovation theory

Innovation studies in the built environment are predominantly based on the underpinning philosophical assumptions central to the prevailing economic theories of innovation: neo-classical theories (with the early champions being Griliches and Mansfield) and evolutionary theories (developed from the pioneering work of Nelson and Winter). The fundamentally most important assumption that these theories bring with them is that of a set of commonly accepted criteria regarding the merits of the innovation on which potential adopters and relevant stakeholders agree. These models of innovation are evidently appealing in their universally applicable linear nature and their adoption accentuates a realist, rational and deterministic view of the world. The underpinning assumption is that strategic decisions and selections are based on rational choice. Clear distinctions are presented as being in place providing useful boundaries between the various phases that the innovation is seen to go through on its journey from idea to widespread use. Complementing this assumption is the idea that individuals will behave in a consistently rational manner based on notions of self-interest (Nelson et al. 2004). Thus, based on the existence of the commonly accepted criteria individuals will make rational decisions. These decisions can therefore be predicted and their material outcomes can be modelled. A substantial number of publications show clear tendencies of portraying innovation as something that could be achieved and explained through the rational use of frameworks and models. These are reliant on specific innovation success factors being brought into place. Indeed, the majority of reports on successfully implemented innovations provide explanations in the form of adherence to certain formulised routines consisting of discrete actions undertaken in a sequential and bounded manner. What they have in common is that they presume the presence of efficient selection process and outcomes rather than studying the processes or outcomes directly.

Of course not everyone adheres to the 'economist' view of the world and notable exceptions can be found in the built environment literature. In simple terms, this alternative line of thinking is based on the belief that the economist's objective 'yardstick' (cf. Nelson et al. 2004) does not exist. Instead, it is assumed that innovations, be they technological or process oriented, have interpretive flexibility and any evaluation of the innovation therefore is socially constructed and a result of negotiations between individuals. A further important assumption is that the perception of the merit of the innovation shapes and is shaped by the adoption process and accordingly changes over time and organisational and societal boundaries; accentuating the move towards increased focus being given to context. Thus, notions of interpretive flexibility and structure/institutions play a central part in their arguments. As a consequence it is not unconditionally accepted that successfully implemented innovations could be explained by the adherence to certain formulised routines consisting of discrete actions undertaken in a sequential and bounded manner. Instead, innovation is seen as context sensitive and it cannot readily be extracted from the various contexts within it takes place e.g. personal, environmental, organisational and technological. Furthermore, innovations are believed to change over time as they are adopted, implemented and taken into practice.

In line with this latter view of innovation, we suggest that a greater understanding of the diffusion of innovations, in the specific case of individual laptops, can be achieved through complementary approaches that set out to understand the respondents' environments and the social interactions that form part of their daily routines. This follows from the common argument that the physical environment plays an important role in shaping behaviour in schools (e.g. Day and Midbjer, 2007);and builds on a long tradition of studies targeting the impact of the built environment on performance in general and the benefits of good design in particular (e.g. Herzberg, 1966).

4.2 The role of learning environments

Development in pedagogy and educational approaches is too wide a topic to be dealt with in an article such as this (for more detailed exploration see Leiringer and Cardellino, 2011). Suffice to say that the existence of a link between aspects of the facilities and school effectiveness and educational outcomes is increasingly recognised in the literature. There is no shortage of studies that have sought to establish a relationship between the physical environment in which pupils learn and the learning outcomes associated with these environments (cf. Higgins et al., 2005). The majority of these studies have focused on the tangible physical aspects of design and its functionality; exclaiming correlations between the physical school environment and improved levels of teaching and learning. For example, increased use of natural ventilation and lighting and attention to acoustics has been found to support concentration and overall pupil performance (Woolner et al., 2007). A near consensus seems to exist on that basic physical variables (natural ventilation, colour, temperature, etc.) have an effect on learning (cf. Higgins et al. 2005). Clear links are as such drawn in the literature between the improvement of poor learning environments and increased pupil motivation and attainment.

While it is seemingly axiomatic that basic physical characteristics affect pupil perceptions, any study of the impact of the physical environment on education needs to take into consideration the complexity of the school environment. In the immediate school environment, the physical environment is as much a social phenomenon as it is a physical one. Behaviour is also influenced and constrained by pedagogical, socio-cultural and motivational factors amongst others. In truth, the relationship between people and their environment is complex and multifaceted in nature and it makes little sense to think about physical space without considering how it is used (Sztejnberg and Finch, 2006). School buildings provide for a variety of social groups within their premises. Spaces govern and support interactions between these groups and individuals. Ultimately, spatial design both facilitates and inhibits behaviour and relationships between different actors (cf. Penn et al., 1999).

Aspects of the physical environment, such as classroom and school size, and the degree of openness of the spaces also have an impact on educational outcomes. The social interaction within these spaces is commonly put forward as a critical factor in establishing the relative success of the learning environments. The importance of understanding the link between education and the design, condition and use of learning spaces is deemed crucial (e.g. Woolner, 2010). A plethora of studies have indeed tried to establish the extent to which teachers make use of available spaces and the degree to which the physical environment dictates how they teach (e.g. Moore and Lackney, 1993). Whilst there is relatively strong agreement on the existence of a link between the style of teaching and classroom organisation, the findings differ on the implications. For example, in the case of the open-plan movement in the UK in the 1970s, some commentators were adamant that more open classrooms have a direct effect on how teachers teach; others argued that the strong policy push and the provision of classrooms with more flexible layouts did not radically change behaviour as many teachers kept to ‘teaching from the front’ and did not alter the disposition of the furniture. In short, the tendency simply to cope with the given environment rather than actively attempting to manage it should not be underestimated (Higgins et al, 2005).

5. Initial insights from an ongoing case study

The paper draws on an on-going longitudinal multiple case study set up to investigate the role of the school facilities and their immediate surroundings in mediating the successful introduction and adoption of individual laptops. The case study consists of five public primary schools, chosen through purposive sampling. Two of the schools were completed after the announcement of the Plan Ceibal and are located in what are considered to be critical areas of the capital Montevideo. The three other schools are much older and are located in areas with very different socio-economic conditions. It is worth briefly describing the schools as to provide a picture of the very different settings in which Plan Ceibal is rolled out. Case 1 (Estados Unidos de América) is located in the town centre of Montevideo in a middle class area. The school has 362 pupils and 12 teachers. The school facilities date back to 1930, the classrooms are large but the condition of the building is only just acceptable. The school received the XOs in March 2008. Case 2 (La Palmita), is a rural school located in a remote area in Canelones, a neighbouring state of the capital, Montevideo. The school provides for 77 children between the ages of 4 and 12. The facilities are old, lack modern amenities and in dire need of maintenance. The XOs were received by the children in March 2008. Case 3 (School number 41) is located in a poor to middle-class area of Montevideo and houses 260 children and 17 teachers. The facilities are old and in need of maintenance. It is the first school in Uruguay to become a full time school where the children go to school from 8am to 5pm. Case 4 (School number 330) is located in a deprived area in the outskirts of Montevideo. It is a new build school that first opened its doors in March 2009. It provides for 312 pupils aged 6 to 12 with 15 teachers in total. The pupils already had XOs when they started in the new school. Finally, the ‘new build’ School number 376 (Case 5) is situated in a western suburb of Montevideo opened in March of 2010. It hosts 200 pupils from 6 to 12 years old from a catchment area characterised by very low family incomes. The XOs had already been used by the children in their former schools.

The study is set up to study changes over time with field work carried out at intervals of 6 months. The first phase of the fieldwork was conducted in May - June 2011. A variety of data collection techniques were used. To start guided tours were taken of the school buildings and grounds. These were given by the head teachers. In the case of the new build schools the responsible architect also provided a separate tour explaining the thinking behind design features. Classes were observed both directly with the presence of the researchers being known to the children and teachers, as well as less intrusively from a distance. Observations were also made of other activities undertaken in the school and a series of informal discussions with teachers and other end-users were held. The observations followed a predefined observation protocol and were recorded separately by two researchers. This provided for an understanding of the use of the XO within the classroom environment and surrounding areas. For each of the cases interviews were also undertaken with the head teacher, three teachers and the designated Plan Ceibal champion amongst the staff. Photographs were taken, where appropriate, in relation to the use of the XO, as additional information, enabling the particularities of each case to be recorded. Added to this, the research team were also provided with 3 different types of

XOs to enable a better understanding of the particularities of the technology. What follows are brief summaries of the findings in key areas from this initial phase.

5.1 Conducive learning environments

The physical condition of the facilities varies greatly between the schools. The facilities at the three older schools are in need of urgent maintenance and refurbishment. Much of the lighting is in the form of natural lighting coming through big windows. In most cases there are no shutters or curtains. Pupils with desks nearer to the window experience direct sunlight making it difficult for them to read what is on the screen. The battery life of the XO is 2 hours. On average there are no more than two electricity sockets per classroom. In general, classes are large and classroom size is small, creating a cramped environment that makes it difficult for the teacher to move around the classroom. The desks are small and do not provide adequate workplace even for a single pupil. It is common that the desks are shared by at least two pupils. There are no social spaces conducive for using the XOs outside the classroom. The communal areas are very basic and there are only a few benches scattered around the playground and the school halls.

Unsurprisingly, the facilities in the new build schools are in much better physical condition. These schools were designed after the introduction of the Plan Ceibal. However, the Plan did not feature in the brief or any of the formal regulations or norms and the only change vaguely attributable to the programme is that there are four sockets in each classroom instead of two. There are plenty of windows with curtains providing natural ventilation and lighting that enables pupils to work in acceptable conditions. The classroom size is large enough to provide a degree of flexibility. The teacher and pupils have the possibility to move around and it is easy for them to reconfigure the desks. Outside the classrooms there are benches and seating possibilities allowing for the potential use of these spaces for learning. However, the acoustics in these areas is poor making it near impossible to use them for pedagogical purposes.

5.2 Shared perception of merits

The introduction of the XOs provokes mixed feelings amongst teachers and staff. Some have fully embraced the laptops, but many feel uncomfortable with the technology and experience difficulties in incorporating the XOs into the day to day teaching. In all schools there are examples of teachers not being confident in how to use the XO, and thus not using them. More commonly though teachers feel constrained in how the laptops can be used. For those who have adopted the XOs in their teaching the dominant mindset is to consider it to be an ‘instrument’ to teach, a resource similar to the pencil, the whiteboard and the book. The laptop is, thus, not seen as an innovation that invariably will improve the quality of education. Instead, the introduction of the new technology is portrayed as a challenge.

6. Discussion and concluding remarks

It seems evident that the successful role out of Plan Ceibal is dependent on the changes asked for being compliant with the context into which they are introduced. It is even more evident that what previously might have been adequate learning environments no longer can be considered to be so. The two very brief summaries presented above show that there is a multitude of ways that the physical environment can support or impede the introduction of laptops and associated pedagogical ideas in forming effective learning environments. Some of these impediments come across as fairly trivial, e.g. how the use of the XO in the schools is limited by the access to electricity. The batteries of the XOs last for two hours. This effectively limits the use of the XOs to two hours per day as the capacity in the schools to allow for the batteries to be charged is insufficient. Classroom activities that include the XO therefore have to be planned in advance, and work on the basis that the pupils bring their XOs fully charged each day. Likewise, lighting solutions that have worked well in the past are no longer suitable. Adding curtains to avoid sun glare is easy enough, but this necessitates the provision of additional lighting.

With the introduction of XOs teachers are forced to start to move more around the classroom to check the work on the screen of each pupil. The relation teacher-pupil therefore becomes more fluid. In bigger classrooms this interaction happens naturally. In the older schools with small classrooms the spaces start to feel very cramped. Individual work spaces and classroom layouts that were designed for conventional ‘teaching from the front’ are no longer as effective in this new teaching scenario. The scope for doing something different in order to achieve learning environments that respond to the introduction of the new tool is thus severely limited. Redesigning or reconfiguring existing school facilities so that they become more flexible could enable the creation of spaces that accommodate a variety of individual and group activities. This is apparent when considering the bigger and more modern classrooms in the newly built schools. However, it is notable that even though these schools were designed after the introduction of Plan Ceibal the programme did not figure in the design brief. Indeed, no consideration to the possibilities that the use of the XO provides was taken in the design of the classrooms and common areas. Even though these new schools might be suited for the new technology in terms of fulfilling basic physical variables, such as adequate ventilation, temperature, light and colour etc.; they are still not adaptable and flexible enough to support potential changes in teaching and learning that the use of ICT might inspire.

It is generally believed that ICTs can empower teachers and pupils, thus providing potentially significant contributions to learning and educational attainment. Yet, the exact meaning of ‘improve the quality of education’ called for within the Plan Ceibal is not evidently clear. This is certainly the case amongst those charged with teaching and learning. They perceive the introduction of the XOs as yet another tool that helps them in the day to day reality of imparting education, but not as an element that will help them improve education. Nonetheless, Plan Ceibal, undoubtedly, through its wide distribution of laptops has the potential to affect substantial change in society in general, as well as in education. However, its successful diffusion is reliant on it being relevant and aligned to the individual particularities of a broad and divergent school population. The broader institutional context in which the change is to take place and the structural characteristics of the educational sector combine to form unique localised challenges for all involved. The role out of the Plan will therefore not be uniform. Indeed, the introduction of the XOs is context sensitive and it cannot be extracted from the various contexts within it takes place. The affected individuals' environments and the social interactions that form part of their daily routines differ too greatly for this to be feasible. It is not surprising that such reasoning is s marginalized by the high profile investments made in the technology and the logistics of Plan Ceibal. In comparison, investing in the actual facilities and their operation and maintenance comes across as a low road alternative. This we argue is not unique to the Uruguayan context. Indeed, we would go as far as stating that it is the case in all developing countries in which OLPC programmes are being rolled out. A clear case can thus be made for research that allows for a more holistic view of the learning environment. A context sensitive view that not only considers potential changes in pedagogical approaches, but also the physical environments in which these changes are supposed to take place. If the research challenge set out above is embraced and appropriate measures are taken to improve the quality, relevance and impact of research, built environment will have an invaluable opportunity to contribute to the future development of effective learning environments worldwide.

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8. References

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Spatial configurations of healthcare practices

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Abstract

This exploratory discussion paper is motivated by a particular question; to what extent is the relationship between spatial configuration and healthcare practices considered in the design and operation of healthcare infrastructure and healthcare facilities? To explore this, we briefly review three different conceptions of space; space as distance; space as the materialisation of power relations and space as 'lived experience'. We argue that space is overwhelmingly treated as measurable and representable, and that space as reproducing power relations, and space as the locus of multiple interpretations and experiences is largely neglected. These theoretical ideas are largely oriented to understanding existing spaces, rather than the creation of new space to enable different sorts of working practice, and so we go on to discuss phenomenological architectural theory **-** *the notion that design is grounded in the accommodation and enabling of individuals' experience and social practice rather than the functionalistic production of physical artefacts, and problematise the growing body of work around 'healing architecture' as taking a largely passive view of the way clinical practice is shaped by space. Following this, we outline a tentative research agenda to explore the connections between the spatial configuration of healthcare infrastructure and practice beyond space as distance, to consider how infrastructure reproduces specific practices, and engages with its users in multiple ways.*

Keywords: Architecture, design, healthcare, practice, space

1. Introduction

This exploratory discussion paper is motivated by a particular question; to what extent is the relationship between spatial configuration and healthcare practices considered in the design and operation of healthcare infrastructure and healthcare facilities? The PFI programme in healthcare infrastructure in the UK has made a significant contribution to replacing and updating out-of-date and not fit-for-purpose building stock within the NHS and delivering state of the art hospital facilities across the country. But there is considerable debate over the success of the programme in terms of delivering innovation in both infrastructure delivery, and performance. Measures indicate that PFI hospitals show little if any performance improvement, in terms of average length of stay, hospital acquired infection or running costs, over non-PFI facilities. We might argue that this is due to the programme delivering new infrastructure, but infrastructure which reproduces pre-existing spaces and practices, rather than enable new ways of working to emerge.

If we accept this, how might we think about the design of healthcare spaces as contributing to or enabling different sorts of clinical practice? Rather than relegate space to being a generic container of organisations, people and technology, how might it be considered as having a more active role in shaping (and being shaped by) what happens within it? To explore this, we briefly review three different conceptions of space; space as distance; space as the materialisation of power relations and space as 'lived experience'. We argue that space is overwhelmingly treated as measurable and representable, and that space as reproducing power relations, and space as the locus of multiple interpretations and experiences is largely neglected. These theoretical ideas are largely oriented to understanding existing spaces, rather than the creation of new space to enable different sorts of working practice, and so we go on to discuss phenomenological architectural theory - the notion that design is grounded in the accommodation and enabling of individuals' experience and social practice rather than the functionalistic production of physical artefacts, and problematize the growing body of work around 'healing architecture' as taking a largely passive view of the way clinical practice is shaped by space. Following this, we outline a tentative research agenda to explore the connections between the spatial configuration of healthcare infrastructure and practice beyond space as distance, to consider how infrastructure reproduces specific practices, and engages with its users in multiple ways.

2. Space in management and organization studies

"*Space is both the medium and outcome of the actions it recursively organizes: what space is experienced as being limits and enables the possibilities of further social construction within it*" (Rosen cited in Kornberger and Clegg, 2004: 1096).

The relationship between space and practice is a long standing debate not only within urban sociology, but within the field more generally, from the early urban studies of the Chicago School in the 1920s and 30s through the links between social inequalities and spatial distribution of resources to contemporary debates over shifts to late/postmodern society (e.g. Harvey 1989). In organization science and the field of management of the built environment the spatial dimension of organizing has been less developed although the last ten years according to Sydow (2002) has seen some kind of spatial turn. This however has not reached the amplitude and importance of other so-called ‘turns’ in the socials sciences. Sydow (2002) pointed to the fact that the many handbooks within the field organization science, beginning with the 1965 Handbook of Organizations (March, 1965), contain no or only very few entries on space – and when they do it is with reference to works in economic and social geography. This, however, does not mean that space and spatial issues have been of little importance in the practical life of organizations. Kornberger and Clegg (2004) argued that a close look at a classic of management theory demonstrates the importance of space: “*…within scientific management what did Taylor do other than reorganize the spatial arrangement of the entire organization by dividing space into individual cells, so that every single activity had to take place within its own space (cell), separated from the others?”* (Kornberger and Clegg, 2004: 1096). Also Weber’s early focus on the separation of public and private space is drawn on in explicating space as an implicit concern of organization theory. Thus, even though space has long been a concern of organization theory, it has remained a largely *implicit* concern.

In this section we review a number of spatial positions from sociology and organization studies with a view to highlighting the recursive relationship between space and practice. In doing so, we focus on space as both: (i) “*…a metaphor for that period in time when a possibility to actualize (often materialize) an imagined creation is practised in concrete social relations (such as conversations)”* (Hjort, 2004: 418); and (ii) a real-world topography or physical phenomenon. This review will be followed by a discussion of their significance for the spatial configuration of healthcare infrastructure and the implications for healthcare practices which are performed within them.

2.1 Space as distance

Within the fields of management and organization studies, Taylor and Spicer (2007: 325) suggest that existing research can be classed into three categories: (i) studies of space as distance; (ii) studies of space as the materialization of power relations; and (iii) studies of space as experience. Each of these three perspectives entails “*…different methodological preconceptions that shape key analytical concepts and protocols of data collection*” (Taylor and Spicer, 2007: 327). The notion of space as distance, or perhaps wider formulated: space in a physical context of interpretation, is the most studied and developed of the three perspectives in organization and management studies. Conceptions of organizational space as distance are found at several levels of analysis. In this perspective focus is placed on such diverse topics as human ergonomics, workplace design and geographical location, (Tissen and Deprez, 2008) but also research into regional economics and industry clusters (Porter, 1998) draw on a ‘space as distance’ understanding. The basic tenet of the space as distance perspective is Euclidian geometry, which suggests that space is the distance between two or more points, implying that space is treated as an objectively measurable and representable phenomenon (Taylor and Spicer, 2007: 327). What this means is that attention is directed towards sites of investigation where distance and proximity can be easily measured and conclusions drawn based on aggregated data.

2.2 Space as materialization of power relations

Space is however not just a matter of distance and proximity. Seeing space as something that can be objectively measured and represented provides a highly functionalistic understanding of not just space but also the practices taking place within this space. Studies of, and indeed efforts to engineer, organizational space, which are based on this understanding have significant shortcomings (Taylor and Spicer, 2007: 329) in that both unproductive and outright detrimental practices might be (re-) produced. Applying an interpretive perspective Taylor and Spicer (2007) pointed to two shortcomings in particular of the functionalist approach: (i) that ways in which actors attribute meaning and significance to a space is unaccounted for; and (ii) that questions of how power and resistance may shape manifestations of distance and proximity are disregarded. These shortcomings have some important implications. One is that they lead to a lack of understanding between those engaged in the technical manipulation of organizational space (e.g. architects but also managers) and those living within the space (e.g. employees, patients or residents). Another is that "*…we ignore how spatial configurations of distance and proximity are the surface manifestations of deeper level relations of power*" (Taylor and Spicer, 2007: 329). To address these issues Taylor and Spice turn to the 'space as materialization of power relations' perspective.

Rather than just focussing on the visible patterns of distance and proximity and on *how* these surface manifestations of organized space operate, this perspective seeks to explain *what* produces one set of patterns rather than another and thus *why* spaces are configured as they are (Taylor and Spicer, 207: 332). Perhaps the most iconic example hereof is Foucault's (1991) exposition of how the 'panoptic' or disciplinary gaze emerged as a technology of power, a principle of reorganization, designed to solve the problems of surveillance throughout the different spheres of society and how it in spatial terms gave rise to: *"…a type of location of bodies in space, of distribution of individuals in relation to one another, of hierarchical organization, of disposition of centres and channels of power, of definition of the instruments and modes of intervention of power, which can be implemented in hospitals, workshops, schools, prisons" (Foucault, 1991: 205).* Power, however, is not just negative, rule based, and reliant of a uniform and visible power-apparatus. Following Foucault power should also be seen as positive and productive. This means that we can also begin to understand how individuals themselves engage in building spaces that support or part with existing practices and divisions of labour. Thus, it directs attention to the tension between practiced and planned space (Taylor and Spicer, 2007: 331).

2.3 Space as lived experience

In order to understand more in depth how practised spaces come about, we can turn to the 'space as lived experience' approach. According to Taylor and Spicer (2007) this approach moves even further from the assumption that organizational spaces are physical manifestations such as the distance between two rooms. Rather, they argued, space should be understood as: "*…our experience of and understanding of distance and the meaning which we give to walls*" (Taylor and Spicer, 2007: 333).

In order to understand these experiences of space, researchers in organization studies have drawn on resources generated by the linguistic and cultural turn in social science. This entails a focus on i.a. organizational symbolism and organizational aesthetics (Taylor and Spicer, 2007) but also a sense making perspective (Weick, 1995) would be a way to address the issues at stake. According to Dandrige et al. (1980: 77): *"The term "organizational symbolism" refers to those aspects of an organization that its members use to reveal or make comprehendable the unconscious feelings, images, and values that are inherent in that organization. Symbolism expresses the underlying character, ideology, or value system of an organization."*

This, as was the case with the 'space as materialization of power relations' perspective, is a recursive or dialectical process. As symbols may be used to impact users' experiences of space so may users: "*…'rescript' organizational spaces through the deliberate misappropriation and misuse of organizational spaces*" (Taylor and Spicer, 2007: 333-334). An example of the former could be Casey's (1996) notion of a Designer Culture as also discussed by Clegg et al. (2002). It is, however, important to notice that even though some sort of strong symbolism is woven into the fabric of the organizational space, individuals will make sense of the space in multifarious ways. According to Taylor and Spicer (2007) this can due to embodied experience of space *per se* or structural positions in relations of power (e.g. employee/manager), but it could also be attributed to the fact that different individuals or groups draw on different institutional logics as resources in their assignment of meaning to space.

2.4 Making space: Practices of spatialization

The three spatial perspectives outlined above provide different takes on how to understand and conceptualize space in organizational studies but they do not reveal to us how space is produced and how individuals are positioned and position themselves in relation to space (Tissen and Deprez, 2008). Unlike Taylor and Spicer's (2007) suggestion for a theory of the production of space that builds on a notion of working with scales (macro-meso-micro) we turn to a classification or 'trialectics' of spatiality (Hernes, 2004; Tissen and Deprez, 2008: 44).

Table 1: A trialectics of spatialization

Spatialization	*Definition*	*Spatial approach*
Practiced space (Spatial practice)	*Space in its specific form, which embraces production and reproduction.*	*Space as distance*
Conceived space (Representations of space)	*The dominant space in any society, which is tied to the imaginaries of people in power, the producers of space. May consist of e.g. ideologies, rules and structures used to map the ordering of processes.*	*Space as manifestation of power relations*
Lived space (Representational space)	*Spaces that evolve from our historical past. Tacit and taken for granted and consisting of subtle non-verbal signs and codes through which we make sense of the world.*	*Space as lived experience*

This trialectics of space (Table 1 above) has the advantage that it situates spatial practices across scales (Jessop, 2007) thus not privileging any specific ontology in a practice of spatialization; i.e. in the process of making space. Space might be determined by scale but its properties apply across scales. The three spatializations are based on Lefebvre's (1991) notions of lived space, practiced space, and conceived space. The argument is that organizational space is produced and can be explored empirically by focusing on "…*practices of distance and proximity which are ordered through planning and interpreted through the ongoing experience of actors*" (Spicer and Taylor, 2007: 335) i.e. through the processes of: (i) practicing, (ii) planning; and (iii) imagining that correspond to the approaches to space treated in the literature review.

Within the field of management of the built environment there is a tendency to observe space as the outcome of social action neglecting the fact that space is always in the making and that space matters. Here space is mostly understood in its specific form as a physical building or construct that has to conform to certain objectively representable and measurable requirements. By drawing attention to the way that people then engage in the space they live and experience and also focus on unpacking and explicating the motives and ideologies of stakeholders and decision makers we can get a more robust understanding of *why* certain spaces are configured and hence *what* produces one set of social and spatial patterns rather than another. This is not just interesting in an after the event, academic sense but also something that has practical implications. Surely it is interesting from an intellectual viewpoint to be able to unravel what possibly minute detail led to a decision of a spatial solution that has attained a highly normative status or taken-for-grantedness. There is however also a functional side to such an understanding in that designers can use it productively in a design process, e.g. to ensure that voices of the minorities are heard or that stakeholders become equipped with a new vocabulary with which to engage their own presuppositions. Such an approach is (partly) addressed in phenomenological architectural theory, which we deal with in the next section.

3. The treatment of space in healing architecture

Architecture is, if anything, the art or discipline of spatialization. In this section, we apply the framework to a case study of how space is understood and practiced in the architectural production of a clinical space for healing architecture. We start by a brief exposition of phenomenological architectural theory that provides an important cornerstone for the understanding of how lived experience is reflected in architectural practice.

3.1 Phenomenological architectural theory

Architectural theoreticians like Pallasmaa (2005) and Pérez-Gómez and Pelletier (1997) have foregrounded the body and the bodily experience and perception of space and form as decisive for our experience of architecture and the role architecture can and should play. Pallasmaa (2005) formulated a critique of the predominant visual realm of modern architecture with a point of departure in the whole-body and all our senses. He pointed to the bodily perception as the basis for our inhabitation of the world and our cognition and conception of it and of our-selves. For this bodily being-in-the-world, architecture plays an important role: "*The essential mental task of architecture is accommodation and integration. Architecture articulates the experience of being-in-the-world and strengthens our sense of reality and self; it does not make us inhabit worlds of mere fabrication and fantasy*" (Pallasmaa, 2005: 11). Pallasmaa (2005) outlined the various ways our senses perceive and experience architectural space placing the whole-body in the centre of the spatial experience. Such a bodily encounter with spaces is multi-sensorial in that every touching experience of architecture is multi-sensory and that qualities of space, matter and scale are measured equally by all organs. Based on Gibson's (1963) categorisation of senses, Pallasmaa (2005) described five sensory systems through which individuals encounter and interact with their surroundings and with the social context this includes: (i) the visual, (ii) the auditory, (iii) the taste, (iv) the haptic; and (v) the whole-body sense of orientation and scale. Together these five sensory systems provide an important cornerstone in architectural practice as seen most notably in the current efforts to promote *healing architecture* and *evidence-based design* principles.

3.2 Healing architecture

Healing architecture is based on the assumption that space or spatial qualities of the built environment has an impact on the individuals occupying the space and the practices unfolded in the space. This can be either as spatial conditions that frame the practices such as walking distances for the staff in a hospital department, or as sensory stimulation that can impact persons psychologically or physiologically, and thereby their experience of well-being and their healing process. Within the last ten years healing architecture has met increasing interest from healthcare providers, due to the recognition that the layouts or spatial qualities of hospital settings impact healing and improve outcomes, thus improving healthcare efficiency and reducing costs. Theoretically, the concept however seems somewhat 'blurred' when it comes to how the relation between space and its impact on persons and practices is understood. This lack of clarity is reflected in the selection of distinct spatializations that are included as potentially healing in the various treatments of the concept. Ulrich et al. (2008) e.g. operate with three categories of spatial impacts: (i) improving patient safety through environmental measures, (ii) improving other patient outcomes though environmental measures; and (iii) improving staff outcomes through environmental measures. Included in these categories are a mix of spatial impacts on practice and outcomes e.g.: (i) logistics, such as the impact of flexible patient rooms on amount of patient transfers, (ii) technical issues such as ventilation systems significance for airborne transmission of infection, (iii) sensory stimulation from daylight, sound and noise; (iv) and functional issues such as securing patient privacy.

In contrast, other treatments of healing architecture drawing more explicitly on phenomenological architectural theory outline the concept differently. Here focus is on the stimulation of the body and its senses, leaving out issues regarding the logistic and the technical functionality of the layout (cf. Frandsen et al., 2009). Attention is rather directed towards (i) the sensorial impacts of spatial qualities such as daylight, views and access to gardens and vegetation and (ii) the spatial qualities of functions such as personal space that establishes a sense of territory that secures intimacy and confidentiality and allows the individual some degree of self-regulation of the physical surroundings (turning on and off light, open window, regulating the temperature etc.). The empirical data used to argue for the relevance of healing architecture and the definition of the spatial variants, comes from many scientific traditions such as medicine, psychology, environmental psychology, architecture etc. Some of the studies are controlled randomized experimental studies of one environmental factor; others are observation or interview studies of many environmental factors. This diversity adds to the ambiguity of the concept. Typically, the studies are specific when it comes to patient group and the measurement of variables, but leave out information on the spatial context, adding to the difficulty of converting the knowledge about impacts to knowledge about space.

3.3 Spatial aspects of healthcare and clinical practices

While healing architecture constitutes a specific design concept that deals with the relationship between space and practice, it does so primarily from a space as distance perspective. Healing architecture bears with it certain images of what constitute proper or indeed beneficial healthcare practices on behalf of patients as well as clinicians. Even though we could argue that this approach is based on phenomenological principles, focusing on lived experiences, this is to some extent lived experience by proxy in the sense that they are deduced secondary effects of a certain medical gaze rooted in an evidence-based rationality that very much works from a perspective of the measurable and the representable. Thus in order develop a more nuanced and, in terms of the spatial perspectives outlined in this paper, fuller understanding of how 'healing spaces' are shaped by and affect the healthcare practices taking place within them, emphasis also has to be placed on developing design concepts that draw on the other spatial understandings as well.

4. Towards a research agenda

We develop in this paper a tentative proposition – that the active making of space – through design – can contribute to the development of innovative practices within them. What we have attempted to achieve through the discussion above is to make connections between different conceptions and understanding of space – as something other than functional representations of proximity / distance - and sketch out some implications of this for design rather than understandings of existing spaces. We now return to our original question; to what extent is the relationship between spatial configuration and healthcare practices considered in the design and operation of healthcare infrastructure and healthcare facilities?

4.1 Space as distance in healthcare

As we have argued, space as distance is the dominant and arguably most straight forward conception of space, and the area which currently has the greatest critical mass in terms of research activity. Examples of this type of approach might include measuring, mapping and modelling demographics and transport routes at regional or city scales in order to ensure that hospitals are located as appropriately as possibly in terms of accessibility and coverage. At a different scale, we might focus on the organisation or building, to follow the flow of patients, porters, visitors, doctors and nurses in a hospital and trace their movements in order to develop floor plans that would reduce walking distances and improve flow of people through the space. This type of approach has also been used to monitor the circulation of people within hospital wards, coupled with microbiological sampling of healthcare acquired infections at various points (bed rails, door handles, sinks etc) to map contact-based transmission routes. This can lead to improved design solutions to avoid transmission ‘hot spots’ and reduce cross contamination. A final example could be concerned with the layout of wards and visibility of patients to staff; e.g. where to place nursing stations in relation to rooms and nursing beds in order to ensure efficient monitoring of patients. This type of approach to space is regular found in both research and practice around design of healthcare infrastructure.

4.2 Space as materialization of power relations in healthcare

If we move to conceptualising space as the materialisation of power, we shift our attention to issues around individual and professional identities, organisational or institutional logics and routines, and the way spaces such as hospitals contribute to their (re)production. There is already an extensive literature around these issues, some of which, such as Foucault’s notion of the Panopticon, draws heavily on spaces as reinforcing dominant ideologies. Within construction management research, the way in which professional practices, identities or indeed subjectivities are construed and constituted has begun to gain prominence (cf. Brown and Phua, 2011). In organization studies it has long been acknowledged that there is a potential link between organizational identity and individual identity (e.g. Kärreman and Alvesson, 2001), and space and identity, for instance Alvesson’s (1994) discussion of the way the ‘newsroom’ was integral to the construction of journalist’s professional identity. In an empirical study of doctors and nurses working in the British National Health Service (NHS) Halford and Leonard (2006) showed how spatial context shapes the construction of professional workplace subjectivities. This is important in the sense that it shows how professional identities and practices can be ‘spatially engineered’ and reproduced, and how people are controlled through the configuration of organizational spaces. The implications here for the design of healthcare spaces is that if such spaces are able to reproduce and reinforce particular power relations, for instance those between doctor and nurse, and support particular practices or divisions of labour, so might new spaces have a role in cultivating and producing new forms of relationship and practice.

4.3 Space as lived experience in healthcare

Finally we turn to space as conceptualised through multiple lived experiences of actors within it. An important aspect of the ‘space as lived experience’ approach is that we can begin to reveal the contours of the contrasting rationalities, discourses or different institutional logics that meet and intermingle in the design of organizational spaces. A project is to some extent a compromise; a negotiated enterprise in which various interests and experiences of multiple stakeholders have to be juxtaposed and balanced. In the case of hospitals political, medical (including care), economic, social and human concerns all have to be considered. For each stakeholder, these experiences and logics are drawn upon to give meaning to a space, and it is these meanings which are brought together through processes of design. Two questions emerge from this; how might exposing these resources allow new healthcare spaces to align with specific experiences and meanings, and how might this aid an understanding of the compromise and negotiations which inevitably happen within multi-stakeholder interactions?

4.4 Mobilising space and practice in healthcare infrastructure design

We have identified a number of themes or interests around which space and practice might be more closely linked, and more substantively engaged with, through research. But what might that look like in terms of specific research activity? We now indicate some specific areas where this multiple conceptions of space and their relations to practice might be mobilized. The first is in rethinking approaches to stakeholder management and engagement within design and construction processes for healthcare projects. The broad trajectory of stakeholder engagement research is around improving the relationship and understanding between users (doctors, nurses, patients) and designers, but we might argue that this merely results in clinical spaces which reproduce the existing practices, power structures and identities of those stakeholders, rather than challenging and transforming them. A second related aspect could involve examining the artifacts and processes which are used to develop and communicate designs (scale drawings, CAD and physical models, presentations, formal meetings) as mechanisms which constrain the process, again replicating existing spaces and practices. The use of more ‘open’ and exploratory tools (e.g. immersive virtual reality systems) could serve as a way of releasing some of these constraints to allow new ways of thinking about space and practice to influence design. How might the use of less specialist design tools shift the power relations between clinicians and designers? A third aspect might examine the nature of projects themselves in this way, for instance exploring the use of partnering mechanisms to open up alternative fora for dialogue around designing healthcare spaces. A fourth area would be tracking and tracing patterns of practice and professional identity across different spatial configurations. Making changes in the design of wards affects not only patient healthcare but has also implications for the professional identity and tasks of the nurse. A shift from a Nightingale ward style hospital configuration to single room layouts might be predicated on medical concerns and improve cleanliness and patient comfort (cf. Pattison and Robertson, 1996), but at the same time transform the nurse from a carer to a caretaker being tied to their nurse stations and secluded from interaction with patients and other staff (cf. Halford and Leonard, 2006). How does reconfiguring ward spaces impact on professional identities, or upon the experiences if patients and visitors? A final trajectory might consider domestic care, and the way individual and family experiences of domestic space are affected and transformed through the introduction of often intrusive remote care systems.

5. Conclusions

This paper was motivated by a specific question; how is (and how might be) the relationship between space and practice considered in the design of healthcare facilities. Following Taylor and Spicer (2007), we briefly sketched out a trialectics of spatialization; space as distance, space as power relations and space as lived experience, as an expansion of the dominant way of seeing space as something measurable and functional. When applied to the design of new spaces within healthcare settings, we would argue that the trialectics approach provides an opportunity to investigate and incorporate multiple perspectives, identities and rationalities into understanding how healthcare spaces are designed, and to think more broadly about the role of space in both reproducing, and therefore transforming, healthcare practices. A key aspect of this is the ability to incorporate different types of data, and theoretical perspectives into the analysis; such as monitoring of people flow revealing patterns of movement and interaction alongside more interpretivist accounts of the construction of professional identities and divisions of labour, or analysis of lines of site in ward spaces combined with capturing the lived experiences of patients, visitors or nurses. We see many opportunities to develop research supported by this framework, which could have considerable practical implications for providing innovative new healthcare spaces alongside innovative practices.

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Towards a new role for building materials manufacturers in construction projects - a case study of energy requirements

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Abstract

To meet the expectations of demanding clients, new project-delivery configurations have been developed. Concurrently, the building sector faces increasing demands from building authorities, most recently in the shape of the new requirements to energy performance as implemented in the Danish Building Regulations. Approaches focusing on performance-based building or new procurement processes such as new forms of collaboration between actors in construction projects and the development of integrated solutions are considered solutions that improve the industry's overall performance. Often building materials manufacturers are perceived, not as part of the construction project, but as suppliers of the construction project and their traditional target groups are architects and consultants. This paper focuses on new types of collaboration between a construction project and building materials manufacturers, where building materials manufacturers are oriented towards clients through direct cooperation, or new types of services aimed at clients. The research investigates the consequences for construction projects and actors. The research is based on qualitative case studies of major manufacturers of building components towards new roles in construction projects. The analysis shows firstly that building materials manufacturers can take on different roles in procurement processes from new ways to collaborate with the client to offering new types of services to the client. Secondly, the analysis shows that building materials manufacturers – in the new role - influence the innovation process. Thirdly, the analysis shows that in order to understand the relationship between regulation and innovation in the construction project, and to identify new ways to promote energy innovation in construction, it is not sufficient to examine the project-based companies' opportunities for innovation, including how they can reclaim the chain, but it is equally important to examine the building materials manufactures' capacity for innovation and how this innovation affects the chain, i.e. a symmetrical analysis.

Keywords: Building performance, Green buildings, Innovation, Procurement, Regulation

1. Introduction

Improving building energy performance is perceived as a central part of the solution to climate change. In Denmark, building energy performance has long been in focus, initially prompted by the energy crises in the 1970s and today based on environmental and climate debate. Since then, energy strategies as reflected in the Danish Building Regulations have changed character reflecting differences in the understanding of the problem and possible solutions, who are the relevant actors, how must the phenomenon be defined and governance structure used. Overall, one can describe the evolution as a shift from prescriptive regulation to performance-based regulation.

Regulation affects individual companies and overall delivery system innovation and it is clear, since regulation is part of the institutional context in which companies operate. The question is how regulation affects the respective individual company and innovation in the overall delivery system, including the relationship between companies in the overall delivery system. The building industry is characterised by delivering complex products in complex production systems that often distinguish between project-based companies (architects, consultants and contractors) and industry-based companies that provide building materials and components for the building project (Gann & Salter. 2000).

This paper builds on the hypothesis that the relationship between regulation as a driver of innovation of the materials manufacturers in the construction industry and the importance of innovation for the building project is not sufficiently elucidated. Existing analyses of the regulation's impact on innovation in construction projects is often based on project-based companies and not the suppliers (see e.g. Gann et al. 1998). This results in the focus of analysis often being on how the project-based businesses can require demands directed upstream in the supply system as part of an innovation process. Therefore, there is a lack of knowledge about suppliers' influence and role in the innovation process in the construction project.

This paper addresses first the importance of building regulations as a driver of innovation among building materials manufacturers and second, how this innovation influenced the construction project, i.e. downstream in the delivery system. It is concluded that in order to understand the process of innovation in the building project, it is equally necessary to understand building materials manufacturers influence downstream in the delivery system, as it is to understand the project-based business requirements directed upstream in the delivery system.

2. Methods

This paper intends to identify key theoretical and empirical issues that can support further research into energy regulation and innovation in construction. Since energy is a relatively new field compared with other regulatory areas of the Danish Building Code, such as safety and fire conditions, it also contributes to the elucidation of the development and stabilisation processes in the interaction between regulation that drives innovation and the importance of construction. It is assumed that regulatory initiatives within energy play a significant role in the actors' understandings and interpretations of the relationship between construction and energy, among other things confirmed by a Danish survey on standard-house manufacturers' innovation where innovation in energy appeared as one of the main areas of innovation in recent years. The manufacturers saw the new energy requirements of the regulation as the main reason for innovation within energy. Other important areas of innovation such as design and planning manufacturers stated to be market driven to greater extent (Forman et al., 2011). This does not mean that the study cannot contribute to the more general knowledge about the relationships between regulation as a driver for innovation and innovation in construction and the importance of new forms of procurement and construction management, but the study's particular strength is the knowledge of the implementation of new areas where the building industry as a system is under pressure.

The analysis was conducted as a case study focusing on the shift from descriptive energy regulation to performance-based energy regulation and the shift's influence on the building materials manufacturers' innovation.

In order to describe the evolution of energy regulation in the Danish Building Code, the various building codes were reviewed and additional literature was studied. When reviewing the various initiatives in the Danish Building Code, the development was analysed to identify changes in regulation.

We then turn to a case study describing the interaction between regulation and innovation activities in Rockwool - a large building materials manufacturer. Rockwool A/S has many features in common with other suppliers of materials to the building sector. These are often large companies with their own product-development departments and marketing departments. They supply components to the building sector, and their most important target groups are usually architects, consultants, contractors and DIY people. In this sense, the case is paradigmatic and the experience gained from the case can be generalised concerning other similar manufacturers. To describe the interaction between regulation and innovation activities, documentation from Rockwool's website was used as well as newsletters, articles from the technical press and interviews with employees at Rockwool.

3. Theoretical perspectives

3.1 Construction and innovation

Buildings are generated by integrating many products and services that together form a complex product system (Gann and Salter 2000). Unlike traditional industry, the dominant mode of production in construction is project based, where a large number of independent companies have to operate in networks with complex interfaces. Gann and Salter (2000) point out that as a consequence innovation, performance and competitiveness depend not only on the individual company, but the interaction across the network between clients, architects, consultants, contractors, building component suppliers and end-users, etc. There are major differences in the conditions of the individual building projects, and it affects the different actors' ability to plan and execute construction and their ability to be innovative. Conditions that may affect are for example, differences in building type (detached, multi-storey buildings, unique buildings, etc.), differences in the size of the building case (if the building case is new or a renovation project), or differences in the tender forms and the clients position in the project organisation.

Rohracher (2001) suggests that an approach to understanding the opportunities and constraints to innovation in construction is to analyse the building and the actors involved as a socio-technical system, i.e. to analyse dependencies and conditions, but also interests, perspectives and stakeholder interaction. Typical concepts used in analysing socio-technical systems are concepts such as critical issues, technological style and technological momentum. Rohracher (2001) suggests that one can make analyses at two levels: 1) the national and regional level and 2) the project level. In connection with the national / regional innovation system, the interaction is weighted between industry, government and market together with the regulation and education, financial instruments etc. With the project level as a socio-technical system, the focus will be on each construction project. Rohracher (2001) suggests that traditional buildings as technical systems are different from other artefacts such as cars, because there is not in the same way a close technical relationship between all sub-components, which reduces the requirement for close interaction between the actors. Building systems are therefore more loosely coupled systems, being dependent on the interaction between actors (architects, planners, consultants, contractors, building services, etc.) that, when setting up a project, will be wired up to the project until it is over (Dubois and Gadde 2002).

Gann and Salter (2000) identified three types of innovation driver: 1) Demand for radically new types of buildings and structures. 2) Pressure to improve the ways in which projects can be delivered on time, within budget to specified quality. 3) Competition between companies in construction itself, as firms compete in their quest to secure orders and deliver new product and services (Gann and Salter, 2000 pp. 960-961). One of the questions in this paper is how the driver influences materials manufacturers and affects relationships / roles in the construction project.

Gann and Salter (2000) suggest that there is a growing need for new types of services to support the owner and users' use of complex products and systems in relation to for example management and maintenance of building systems. Gann and Salter (2000)further suggests that it is very consistent products and services that create new opportunities for customers in terms of increased performance and increased value. The market is generally very fragmented in relation to different types of products and the production is driven by demands of clients in the individual building projects rather than the result of arms-length market transactions, which typify consumer-goods industries. This distinguishes it from traditional industrial production and turns the procurement / ordering activity into a particular job in construction. One can therefore talk about the need for special services as early as at the procurement stage of construction.

With the current energy demands and future challenges for the construction for climate adaptation, complexity may well increase. It is often necessary to integrate complex products and systems within existing systems to manage products and systems to function in the context that they form part of. Gann and Salter (2000) suggest that the level of technical complexity increases when new generations of technology must integrate with existing systems. A need arises for new specialisations that can support system integration. The location of the new specialisations can be placed in different parts of companies or between companies; but that it is the project-based companies that are positioning themselves in a role to provide system integration services (Gann and Salter, 2000). In this paper, we indicate that there may be a need to explore the various system integration services that can be developed at different actors.

3.2 Regulation as driver for innovation

A distinction is often made between prescriptive approaches and performance-based approaches. Performance-based building is perceived as a shift from the traditional prescriptive approach, where building parts are described, specified and procured, resulting in a building with an implicit set of attributes. The performance-based approach, on the other hand, sets *"…the criteria that define the level of performance required of the building attributes"* (Sexton and Barrett, 2005:143).

Gann et al. (1998) studied the effectiveness of performance-based regulations in creating an environment for product development in construction. They distinguish between four types of innovation that should be taken into account if the purpose of regulation is to promote technological innovation:

1. Product innovation in the materials and components area, which is often a result of R&D activities by manufacturers. Product innovation is mostly limited to changes that improve the individual product without the use of the product requiring changes in other products.

2. Process innovation is the use of new ways to assemble buildings or install components, and this type of innovation is often the result of designers' and builders' efforts to improve the design and construction process.

3. Configurational innovation: when the existing component parts are combined in new ways to improve performance characteristics. This typically arises in the design phase.

4. Systemic innovation: when changes to a component or subsystem causes the need for changes in other parts of the system to be implemented.

They conclude that regulation has to focus on two approaches with respect to innovation in construction, one affecting innovation at the component level and the other affecting innovation at the whole systems level, and the further conclude:

"The current focus of regulating design and building activities must be able to translate into a system of incentives and certification which encourage a successful flow of ideas between designers and builders responsible for final product development, integration and assembly, and upstream component innovation by materials producers and suppliers." (Gann et al. 1998, p 293)

What remains is a picture with a clear division of labour between building materials manufacturers and project based companies where building materials manufacturers are assigned a role in relation to type 1 innovations, while the project-based companies are assigned a role in relation to types 2, 3 and 4 for innovation in construction. The question is whether this division reflects the recent experience in Denmark?

3.3 Client and users

There is a growing awareness of clients' and users' role in innovation in construction. This is translated into strategies such as “clients as change agents” and “user-driven innovation”. The specific conditions and opportunities under which the construction industry operates are also important for the clients’ and users’ role in construction innovation processes.

Project organisation in the construction industry means that for every new construction project, the corresponding actor network is configured anew. At the same time, the project-based production of the building means that there is an ordering activity in each project about making explicit requirements for building process and design criteria for building. This “ordering” activity can be handled by the manufacturing system, the clients or the end-users. There is thus a need for "mediation" between manufacturers, clients and end-users in the design and construction phase, where mediation can take many forms, involve many players and is marked by the interpretation and negotiation processes taking place in and between the actors (Forman et al. 2011).

In order to perform ordering activity, a particular profession, "the client", has emerged, which is supported institutionally through both regulation where the client is assigned responsibilities and duties, and through an organisation of professional clients in the Client Association in Denmark. It is worth noting that despite this professionalisation and institutionalisation of the client’s role, there is still a struggle about who best represents the users in a building project. The architects can for example rightly argue that they are the ones who through the design process, interpret and translate user needs. This very loose definition of which actor represents the users in a building project can be taken as an indication that the area is not stabilised. This fact supports the need for a comprehensive exploration of all the mediating mechanisms brought into play between production systems, clients and users.

There is an ongoing discussion within building research about who the "users" are in construction. Many highlight both the different actors in the construction process and the various actors who maintain and use the completed building as potential users. This broad user definition can find its explanation in that the building is composed of many processes that turn the architect into a user of the building materials manufacturer’s products in the design process, the craftsman into a user of materials and tools in the execution phase and the end-user into a user of the home (Forman et al. 2011).

As early as 1993, Slaughter (1993) published her study on user innovation among contractors pointing out that contractors were good at innovating in connection with implementation of building components in the construction process and that a special feature was the solutions provided for the integration of diverse components into a unified whole. At the same time she showed that the innovative solutions that manufacturers chose to include in their product solutions were confined to their own product and not the interfaces between the products. Slaughter wrote that: *”User-builders created most of the innovations in this study; They draw upon their extensive construction experience to create new elements which they then employ. This reservoir of past learning appears to provide opportunities for these users to create innovations which are both inexpensive and rapidly deployed. In addition, these innovations explicitly address problems associated with integrating disparate components into a well-functioning whole unit. In contrast, the innovations commercialized by panel manufacturers only change the product and not its connections to other building components.”* (Slaughter, 1993, p 81-82). Slaughter concluded at the time that the building materials manufacturers had the understanding that there was only a very small market for interface innovations. They had a tendency to perceive the interface innovations between different components as specialised applications or customer orders, rather than seeing them as new product development opportunities. This result therefore supports the view of Gann et al. (1998) that building materials manufacturers’ innovation is bound to the individual component. The question is whether it still applies.

4. Case

The following case study focuses on the Danish energy regulation as driver for innovation by a building materials manufacturer. First the Danish Building Code is described in terms of energy requirements. Developments resulted in a change from descriptive regulation to performance-based regulation. Then a description of the importance of a major building materials manufacturer’s innovation process follows. Finally, it is described how the changes contribute to creating and stabilising a new role for the building materials manufacturers in construction.

4.1 Energy regulation and construction in Denmark

Development in energy regulations in the Danish Building Code can be divided into three strategies, each of which represents a shift in perspective on the relationships between energy and construction. A fourth strategy is visible and involved in the description, since it already exists as a plan and idea for the future relationship between construction and energy, and therefore already serves as driver for innovation among the actors in the construction. The four strategies are based on an understanding of a building as: 1) a building composed of elements with a focus on heat loss, 2) a building that consists of building components and interfaces between building components with a focus on heat loss and line loss, 3) a building as a product with a focus on building energy performance, and 4) a building as part of an energy system focusing on the building's interaction with the energy system. The four strategies are described in the following.

4.1.1 A building composed of elements with a focus on heat loss

The first Danish Building Code came in 1961 and prior to this regulation of energy did not play a big role (Møller et al., 2011). In the first Building Code, there was a requirement to the U-value of the building parts. "*The U-value is the amount of heat loss in watts by* m^2 *of the element at a temperature difference of 1 kelvin (or degree Celsius). U-value, the unit* W/m^{m2} *K"* (Aggerholm et al. 2007 p. 11) (authors' translation). These requirements for U-values reflected good general practice in newer buildings at the time. With the oil / energy crisis in the 1970s focus on energy increased and in 1977 the requirements to U-values increased with the intention of driving the market (Møller et al. 2011).

In addition to requirements that were directly relevant for manufacturers, in this period requirements were also introduced that were directed at other players in building. In 1982, a requirement was introduced regarding the insulation thickness and how large window areas may be in a building (Jensen et al., 2007), which is likely to have played a special role for architects and consultants in connection with design and engineering processes. In 1997, an energy label was introduced and an energy consultancy scheme for small and large buildings that affect the market for buildings. In spite of criticism, the Danish energy label served as a model for the European energy label, which replaced the two schemes in 2007 (Jensen et al., 2007).

4.1.2 A building that consists of building components and interfaces between building components with a focus on heat loss and line loss

In 2001, in addition to requirements to U-values a requirement for line loss was introduced to prevent thermal bridges at specific building components. "*Line loss is heat loss through 1 m of the element and measured in w / m K"* (Aggerholm et al. 2007 p. 11 (authors' translation). This meant that the focus of the Building Code changed from focusing solely on the requirements for the individual building elements to dealing with interfaces between building elements, for example doors and windows.

4.1.3 A building as a product with a focus on building energy performance

In 2006, the Danish Building Code (BR06) introduced a new requirement to the energy performance of buildings based on energy frames, which represents a shift from descriptive regulation to performance-based regulation. The use of energy frames as the main requirements of new construction was a result of the EU Directive on Energy Performance of Buildings (Aggerholm et al. 2007.)

Aggerholm et al. states: "*Energy requirements for new construction are based on the energy frames that cover the building's overall need for additional energy for heating, hot water, cooling, ventilation, and lighting are avoided…."* (Aggerholm et al. 2007 p.11) (authors' translation).

And further:

"When calculating the energy requirement takes into account the building envelope, building location and orientation, including daylight and outdoor climate, heating and hot water, building heat accumulating properties, possibly ventilation and climate cooling, solar and solar shading, natural ventilation and the designed indoor climate. In determining the energy requirements may also be taken into account e.g. the use of solar thermal, photovoltaics, heat pumps, condensing boilers, district heating, use of heat recovery and cooling with ventilation at night." (Aggerholm et al. 2007 p.12) (authors' translation).

The total change in BR06 was:

- That an energy calculation has to be provided together with the application for a building permit,
- That new buildings comply with an energy frame provision,
- That specific energy requirements to extensions and larger renovations/refurbishments are complied with,
- That requirements to the tightness of new buildings are complied with,
- That low energy buildings are classified in two classes,
- That new buildings have to be energy labelled before they are taken into use (Aggerholm et al., 2007 p.10).

These requirements are further strengthened in the subsequent changes in the Building Code, most recently with the latest in 2010.

4.1.4 Building as part of an energy system focusing on the building's interaction with the energy system (future)

The images that characterise tomorrow's ideas and plans for a causal relationship between buildings and energy is based on the concept of a smart grid. Buildings are seen in this perspective as part of an energy system, where buildings are not only energy consuming, but also energy-producing and additional buildings have an active role as flexible units in which energy can be used flexibly and stored. One challenge by using renewable energy etc. is to find solutions to the coupling between energy production and the consumption of energy, because energy is produced when the conditions are present such as wind, solar and also difficult to store, which means that it is optimal to consume energy when it is produced. Key solutions in future ideas and plans are flexible and intelligent solutions based on decentralised buffer systems/storage devices and intelligent control of consumption so that the consumer that only has to take place within a time interval, puts stress on the energy system when it is most appropriate for the energy system (www.kemin.dk).

4.2 Examples of innovation by a Danish building materials manufacturer

Rockwool A/S is a major supplier of materials to the building sector. The company develops, produces and sells insulation products and forms part of the Rockwool Group, which operates globally. Rockwool A/S has its own product-development departments as well as marketing departments. Sales are made through dealers. Due to the shift towards performance-based regulation in the Danish Building Code in 2006 Rockwool focused among other things on the classification of low-energy building and the requirement to the tightness of new buildings. Just before the implementation of the new requirements in the regulation, Rockwool collaborated with an architect and a standard-house manufacturer to develop a low-energy-house to demonstrate how it could be done. They also developed an airtightness programme consisting of different products that can be used in the building process to ensure tightness of a building. The tightness programme was developed to meet the new requirements in BR06.

In 2007, an employee at Rockwool Denmark built a low-energy house for his family. As the employee began to focus on tightness and energy in his building project, the product manager at Rockwool saw a possibility for testing the tightness programme in practice. Furthermore Rockwool saw in the employee's project an opportunity for getting into contact with the users in a new and closer way. By following the project at Rockwool's homepage and describing the process as an ongoing story, they could give some practical instructions concerning the problems that occur when you build and have to integrate considerations of energy performance. This was new for many actors and the homepage received widespread attention. The central actors in the building process were the employees, the suppliers and craftsmen. The employees chose all the suppliers and craftsmen. Concerning Rockwool's development of the homepage, the product manager and employees from the marketing division participated. The product manager was responsible for coordinating the product aspects concerning the homepage, including contact to the suppliers, while the employees from the marketing division were responsible for the rest. At the time of the case study, low-energy buildings were not very common in Denmark. However, to ensure an overview of the complex concept, each of the suppliers was asked to write informatively about the specific problem area at which their product was targeted and the solutions provided by the products. By giving the suppliers space on the homepage, the actor network became visible. By linking the homepages you also link information, and the user needs linked information in a complex system, as a guided way of finding his way around the homepages. As the project was connected with Rockwool, a challenge emerged concerning Rockwool's relations with suppliers in general and how Rockwool could avoid favouring some over others. Rockwool cooperates with many suppliers and usually does not favour one supplier over others. To prevent favouring specific suppliers, the communication of the case has stressed that the selection of suppliers is made by the employee, not Rockwool. At that time Rockwool didn’t clarify how this dilemma could be solved in the future about on one hand the wish to participate in projects with other suppliers and on the other hand to treat all suppliers the same. Later Rockwool prepared a list of suppliers whose products met the requirements for low-energy houses. They have limited the list to windows, ventilation, heat-systems and Installations for pre-heating / cooling of the fresh air through soil. Rockwool have developed the list in cooperation with an engineering firm, and suppliers can contact Rockwool if they want to be included at the list. The purpose of the list is to facilitate the development of low-energy and passive houses (www.Rockwool.dk)

4.3 Towards a new role for building materials manufacturers in the construction project/innovation

There are three aspects that will be highlighted here. Firstly, Rockwool developed a new marketing method in which the testing of new products, development of new technical building solutions and promotion of the products are integrated processes that take place in a public space on Rockwool's homepage. This new marketing method required a new openness from the company and a redefinition of the kind of experience that it is possible to share with the market. Second, the development of new types of supplier alliances through the development and publication of a "vendor list" at the Rockwool site changed the notion that all suppliers must be "free and independent". Thirdly, Rockwool’s product was incorporated in a concept of low-energy houses. The virtual network that links products, information and suppliers can shape the frame for concepts of low-energy houses. It makes it possible not only for the professional construction actors, but also clients and users to relate to the whole and to the individual components. This can be perceived as a new type of service to support the building process.

5. Conclusion

Existing analyses of correlations between performance-based regulation and innovation in the construction project is usually based on project-based companies and focus on how requirements for innovation and new types of products and services can be sent upstream in the supply chain. This paper suggests that performance-based regulation to a great extent influences the building materials manufacturers' innovation and they develop new types of services and products in relation to all types of innovation (component, process, configuration and system). This innovation is important for the construction project both in terms of design, engineering and construction, and the relationships and division of labour between suppliers and the traditional project-based companies (architects, consultants and contractors). To understand the relationship between regulation and innovation in the construction project, and identifying new ways to promote energy innovation in construction, it is not sufficient to examine the project-based companies’ opportunities for innovation, including how they can reclaim the chain, but it is equally important to examine the building materials manufactures' capacity for innovation and how this innovation affects the chain, i.e. a symmetrical analysis. This is no less relevant given the challenges that building faces with regard to energy development where the future boundary appears at the system level, requiring the integration of products and services at the system level with even more players and complex problems to be solved and a growing need for packaged product and service deliveries to the users of buildings.

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Construction Mediation as a Developmental Process

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Abstract

This paper seeks to argue that construction mediation has hitherto been viewed and evaluated in a relatively narrow fashion. It suggests that whilst there are numerous and well-known benefits to the process, although these are not always accepted by all commentators, in such things as time and cost savings there are other valuable benefits, benefits that could be considered as in some ways more fundamental.

The paper seeks to argue that construction mediation is, or at least can be, partly a transformative process. It argues that greater emphasis ought to be placed on the 'process' of dispute resolution and the attendant benefits that can result in the construction professional undergoing a developmental and maturing experience through engagement with mediation. These benefits ought to be then considered alongside other, more traditional accounts, of the strengths and weaknesses of mediation. The argument will be developed through reference to currently recognised models of mediation. It will conclude that through the use of mediation in dispute resolution the construction professional can develop both a range of valuable abilities such as enhanced communication skills as well as important mental and social attitudes that create empowerment and may serve as an aid to cultural change.

Keywords: Mediation; Construction; Education; Professional Practice; Transformation

1. Introduction

This paper seeks to argue that mediation has been hitherto conceived in the construction industry, and indeed by practitioners in other related disciplines such as property management, as largely a ‘problem-solving’ mechanism. Whilst this is clearly an aim of mediation there is also the appended danger that the value of mediation is conceived in these terms alone. If this is the case, then its value, or ‘success,’ is conceived very narrowly. The aim of this paper is, then, to argue that there are wider values to mediation in a construction setting. These values can be considered as a ‘family’ of related attitudes, skills and perceptions that can positively affect the persons involved. By affecting growth in individuals an organisational change may follow. This, in turn, can result in a significant ‘cultural’ change in the industry, and associated professions, as a whole as well as having a positive impact on construction education. The paper begins by an overview of the development of mediation and proceeds to consider its current use of mediation in construction. It then considers the question of how mediation success is conceived. The paper argues that both the current practice of construction mediation and the way in which its success is measured are too narrow. It argues that a wider approach to construction mediation is required. Finally, drawing from the literature on ‘idealist’ mediation an account of mediation as a developmental process is developed.

2. Construction Mediation: A brief ‘history’

Alternative dispute resolution in the guise of arbitration has been important to the construction industry since at least the 19th century. However, many have questioned whether, in fact, arbitration has become in recent times ‘litigation without the wigs’ (Speiaght and Stone 2004) due to its increasingly adversarial approach and its similarity to traditional litigation with its attendant cost implications (Latham 1993, Uff 2009). In the UK, despite this discontent there was little evidence of the widespread use of mediation in a number of studies from the 1990s (Gould and Cohen 1998; Brooker and Lavers 1997, 2000). A factor in this may have been the increasing use of statutory adjudication following its introduction in the *Housing Grants, Construction and Regeneration Act 1996* following the recommendations by Latham (1994). There is evidence that there has, though, been some growth over the past decade or so possibly encouraged by a number of well-documented cases such as *Halsey v Milton Keynes* (Brooker 2009) in the light of the implantation of the Civil Procedure Rules in 1998. Brooker (2010:164) suggests that “between 170 and 300 construction mediations [are] taking place annually.” Thus, whilst still small this is not a negligible figure. A recent study, however, by Gould *et al* (2009) suggests that construction mediation may actually be more prevalent than was previously supposed. With there being a lack of any overarching reporting mechanism then the precise numbers of construction mediations can then only be estimated. Mediation clauses can now be inserted into a number of standard form contracts. The JCT Design and Build 2005 (section 9) specifically mentions the option of mediation whilst the ICE Conditions of Contract 2004 (clause 66) has the option of ‘amicable resolution’ alongside adjudication and arbitration. ‘Amicable resolution’ refers to conciliation (under the ICE Conciliation Procedure 1999) or mediation (under the ICE Mediation Procedure 2002) (Uff 2006).

3. Mediation in practice: Advantages and concerns

There are clear reasons for the both the judicial encouragement of mediation and its gradual increase in popularity. Many authors have noted the particular strengths of mediation over traditional litigation or, indeed, over other adjudication based systems. For instance, Brett *et al* (1996) noted the speed and cost savings in relation to both arbitration and litigation. The privacy of mediation, so useful in commercial settings, is also another important benefit although this, of course, also applies to other forms of alternative dispute resolution (Blake e*t al* 2010). Mediation may also bring particular benefits to disputes where there is an on-going relationship to preserve: this is often characterised as being largely the preserve of family or domestic relationships, however, many commercial relationships, from landlord and tenant to employment disputes benefit from the preservation and enhancement of ongoing relationships and construction is no different in this respect (Kurtzberg and Henikoff 1997; Lowenstein 2000; Ezzel 2001). Feinberg (1996) notes its informality and flexibility. This flexibility, which could be termed creativity, is described by Boulle and Nesic (2001):

> "...Parties may agree on outcomes which could never be available as a court remedy. Thus they may agree upon one party performing a personal service for another, on a dismissed employee being re-employed in another branch of the firm, or on one party giving the other an employment reference." (p.40)

Further, a number of studies have reported high levels of user satisfaction with mediation in a number of different areas of dispute (Guthrie and Levin 1998, Wissler 2004). Whilst these benefits are not universally applicable to all construction disputes there appears to be at least the potential for mediation to be a valuable dispute resolution tool in some construction disputes and therefore a prima facie case for its validity as a method of construction dispute resolution has been made.

Clearly, whilst there are many advantages there are others who have sounded a cautionary note. Many of these objections are based around the role of lawyers and other professional advisors in regard to mediation. Genn (2005), for example, noted that some lawyers use their litigation skills in mediation. This can result in an inherently litigious and adversarial approach and one more akin to arbitration. Brooker and Lavers (2005) found that:

> "Lawyer interviewees also report tactical advantages from engaging in mediation. These range from providing the opportunity to examine the strengths and weaknesses of the case to testing witnesses and evidence. The data suggests that lawyers are developing new practices in mediation, such as proposing the process in order to provide proof to the courts of willingness to compromise or participating in mediationin order to send messages to the opposition." (pg 161)

The willingness of lawyers to use mediation potentially as a tactical weapon to further the interests of their clients was also noted by Brooker (2009). A number of concerns were found by Sidoli del Ceno (2010) in a study of commercial lawyers including those who engaged in construction work. The respondents' perception that mediation was not 'real law' was noted as was the fact that the designation 'mediator' lacked status in comparison with 'solicitor' or 'barrister.' Further, there was ignorance of the possibilities of mediation and a feeling that traditional legal culture which emphasised the virtues of conflict and litigation were additional factors that discouraged many from recommending the process and hence may hinder mediation's future growth and development.

There are others who have fundamental rather than practical concerns with mediation. Fiss' famous *Against Settlement* (1984) again assumes that mediation's only benefit is its potential to settle claims and in doing so he accuses the process of compromising fundamental legal rights. Recently, some members of the English judiciary have criticised mediation using a similar line of argument. Lord Neuberger MR in the Slynn Memorial Lecture 2010 argued that the system of civil justice is part of the very constitutional framework of the country and that it guaranteed fundamental rights and freedoms. He argued that:

> "...the justice system is part of our constitutional framework; it is part of government. The delivery of justice is not a service. On the other hand, the provision of mediation and other forms of ADR is a service. To conflate or confuse the two is to make a profound constitutional mistake."

Jackson LJ (2010) whilst again encouraging the use of mediation stopped short of suggesting that it could ever be mandated despite the fact that mandatory mediation is common in Australia, parts of Europe and elsewhere without any corresponding jurisprudential concerns. The assumption here is again that mediation is only about settlement or the final outcome. Certainly two of the most common models of mediation, facilitative and evaluative, are concerned primarily with settlement. This is not the case, however, with other models. These varying accounts of mediation will be considered below and it will be argued that mediation, properly conceived, ought to be considered as something more than merely a tool for achieving settlement.

4. Models of Mediation

There are a number of differing conceptual models of mediation. Indeed, mapping the conceptual ground of mediation appears to be very much a work in progress as there appears to be is no agreed schema. For example, Menkel-Meadow (1995) derives eight models of mediation from existing literature whilst Boulle (2005) recognises four models and Alexander (2008) describes six 'meta-models'. In jurisdictions where construction mediation is in its infancy a facilitative model tends to be favoured whereas those with a longer history of construction mediation (the UK and Australia are cited as examples) an evaluative model is often although not exclusively adopted (Brooker and Wilkinson, 2010: 193). Riskin (1996) describes the facilitative approach:

> "The mediator who facilitates assumes that the parties are intelligent, able to work with their counterparts, and capable of understanding their situations better than the mediator and, perhaps, better than their lawyers. Accordingly, the parties can develop better solutions than any the mediator might create. Thus, the facilitative mediator assumes that his principal mission is to clarify and to enhance communication between the parties in order to help them decide what to do." (P.24)

Facilitative mediation, then, fits the description provided by Menkel-Meadow (1993) as “pure” mediation in that there is no adjudicative direction of any kind or any assumption of substantive expertise by the mediator. This can be contrasted with evaluative mediation. Brown (2003) states that:

> “The evaluative mediator’s tasks include finding facts by properly weighing evidence, judging creditability and allocating burden of proof, determining and applying relevant law, rules or customs and rendering an opinion.” (p.290)

Both these predominant models appear to implicitly depend on an ‘outcome’ being achieved. They can therefore, perhaps, be labelled as ‘pragmatic’ forms of mediation. The outcome is either the final settlement of the dispute or, at the very least, a partial settlement through a narrowing of the issues. Both of these models fail to consider, or at least, appear to ignore other strengths or possible advantages of mediation. Other models, which are here termed ‘idealist,’ attempt to move away from this. Transformative mediation is one widely recognised approach that seeks to emphasise the value of the process itself and which distances itself from the rather narrow results driven conceptions discussed above. It is associated primarily with the work of Bush and Folger (1994) who describe it thus:

> “The transformative approach instead defines the objective as improving *the parties themselves* from what they were before. In transformative mediation, success is achieved when the parties as persons are changed for the better, to some degree, by what has occurred in the mediation process.” (pg 84).

Another model of the ‘idealist’ persuasion seeks to argue that the insights of therapeutic jurisprudence can be productively applied to mediation. Daicoff (2006) is one who has recognised the link between mediation and transformative justice:

> “All of the disciplines comprising the comprehensive law movement share at least two features in common: (1) a desire to maximize the emotional, psychological, and relational wellbeing of the individuals and communities involved in each legal matter; and (2) a focus on more than just strict legal rights, responsibilities, duties, obligations, and entitlements. These two features unify the vectors and distinguish them from more traditional approaches to law and lawyering.” (p.11)

The debate about models of mediation will not be settled here. It is likely to persist and indeed expand as non-western perspectives increasingly add to the debate (Auerbach 1983; Goh 2002; Law 2009; Bagshaw and Porter 2009). These models are, however, central to the issue of what constitutes mediation success.

5. Mediation and Success – A contested notion

The typical approach to mediation success is based on a ‘pragmatic’ or ‘outcome’ model. The well-known work of Fisher and Ury (1981) which focuses on negotiated outcomes is of that school. It is also exemplified in numerous empirical studies. This pragmatic model is typically based around the number of cases that 'settle.' It appears that the 'fact' of settlement is considered to be central in most cases rather than any perceived qualitative aspect to the settlement itself. For example, Prince (2004) in a study of court-based mediation at Exeter County Court found that 70% of cases referred to the small-claims track in her study settled. This implicitly focuses the 'success' of mediation in terms of the rates of settlement although Prince does later raise other criteria and importantly notes that "there is not an obvious correlation between settlement and satisfaction." (p76). Wissler (2004) in a survey that examined ten separate small claims mediation studies found again that "virtually all studies examined the rate of settlement in mediation." However, other aspects were also examined. For instance, a number of studies sought to explore the impact on the parties' relationships with each other. Further, many studies surveyed sought to consider the views and perspectives of the parties themselves. It is this aspect of mediation 'success' and the wider value or values that emerge from it that is perhaps the most enigmatic and hence the hardest to assess.

Importantly, Shepherd (1984) divides the concept of mediation success into two aspects – process and outcome. Clearly, it is the latter that has been the focus of most mainstream empirical studies which has understandably lead to the process aspect being somewhat under-considered. Furthermore, it is this outcome based approach with what can be termed its 'concrete' aspect of whether an agreement has been made or not that has come to dominate judicial thinking as was noted above. This fundamental assumption that outcome or settlement is the only driver of mediation has also been the basis of many fundamental critiques of mediation as noted earlier. It is perhaps reasonable to agree with Bercovitch (2007) in a study of mediation success where he concludes:

> "Success in conflict management is an elusive quest. Often what appears as successful to one person may be seen as unsuccessful by others. What is more, mediation may seem successful at one time, only to be seen as totally unsuccessful months or years later. We face considerable challenges in thinking about success or evaluating mediation outcomes. As suggested above, there are different perspectives of thinking about success. It seems odd that so many of these perspectives define success in terms of some other equally complex abstract notion. The challenge we face is in recognizing the multiplicity of perspectives, and the different conceptions of, and approaches to, success." (Pg 301)

It is this perspective that is developed below within the context of construction. It will aim to demonstrate that mediation success, which has been largely been conceived hitherto either as something that focuses on measuring the rate of settlement or as something concerned almost solely with personal growth, can actually be considered from both perspectives and that there exists a false dichotomy between 'pragmatic' and 'idealist' forms of mediation.

6. Mediation as development

The argument then has attempted to show that the two most widely used 'pragmatic' models of mediation in construction, the facilitative and the evaluative, are both essentially outcome or settlement based. These approaches largely ignore the process aspect alluded to above (Shepherd 1984). Whilst outcome and settlement are clearly goals of mediation it can be argued that mediation to be properly considered and utilised as a tool for dispute resolution in construction ought to be conceived more widely. This emphasis on process and on the long-term benefits that can ensue from engaging in a non-confrontational and empowering process ought to be given more consideration by construction professionals. This is particularly true in the case of evaluative mediation where the mediator assumes a dominant role. Indeed, some have argued that evaluative mediation is not really a type of mediation at all but ought to be considered simply as another adjudicative method (Currie 2004). The wider benefits that can emerge from the process of mediation have largely not been noted in relation to the field of construction or where they have they have been they have been dismissed (Oberman 2005) although they have been greeted with approval by many in other areas of dispute most notably in the context of family and community mediation.

Brooker and Wilknson (2010:11) argue that transformative and therapeutic mediation “are unlikely to be used extensively in construction mediation” although they concede that “some mediators may adopt some of the techniques within their practice.” The argument appears to be that for these more substantial changes in attitude to take place then more sessions of mediation over a greater time-frame are required and that these are unlikely to take place in a pressured commercial scenario when time is of the essence (Waldman 1998). If one assumes that these methods and processes are mutually exclusive then that may be the case. However, there is little to suggest that a facilitative approach which keeps outcomes as a central focus need ignore the value of the actual process. There is no reason why then they must be seen in opposition. Indeed, by giving greater emphasis to the process, and the wider values that they enshrine, an increase in the actual rate of settlement as participants gain greater understanding of the perspectives of others may ensue (Bush and Pope 2002).

Whilst it is easy to agree that there are at least two parts to mediation – process and settlement – there is perhaps really a third. This can be termed ‘post-settlement’ factors. It is what is taken away from the mediation as a whole including both the process and the outcome. Another model is not being offered however nor is an appeal to the active adoption of an ‘idealist’ model. It is, instead, an argument that mediation properly conceived as facilitative mediation carries with it - implicitly - the wider values argued for by scholars such as Bush and Folger (1994) and Daicoff (2006). Greater emphasis ought then to be given to understanding, assessing and quantifying these ‘further’ benefits of mediation and giving them a more concrete identity rather than dwelling on the potentially abstract notions of ‘transformation’ or ‘therapeutic jurisprudence’. Bush and Folger are aware of this criticism of abstraction but their attempt to move beyond the it nonetheless remains substantially wedded to jurisprudential notions of ‘empowerment’ and ‘recognition’ rather than overtly practical goals that can apply directly to commercial concerns. It is better, then, to use the term ‘educative’ or ‘developmental’ as these terms are more accessible to the construction professional not versed in philosophy or jurisprudence and they carry with it the notion of continuous professional learning that is widely understood. Mediation has the capacity, then, to provide an opportunity for the construction professional to learn and to grow. These are values that are innate but also can provide clear, practical benefits that can be added to the already well-established benefits of mediation as discussed earlier. These benefits, their scope and quantification is a separate task but in order to commence the discussion some possible examples, that are necessarily linked, will be briefly offered.

Communication

Communication is considered to be a central skill and, indeed, a value in construction management (Dainty *et al*, 2006). There are many inherent issues that make effective communication particularly difficult in a construction context, for example, the uniqueness of each construction project and the intensity and short time-scales involved in many contracts, (Loosemore *et al*, 2003). The possibility for misunderstanding because of different 'vocabularies' (Delisle and Olson 2004) and cultural preferences (Muller and Turner 2004) appears to be widely noted. Mediation is fundamentally concerned with communication. By engaging with the process of mediation construction professionals may develop better, more nuanced communication skills which in turn can lead to wider personal development.

Personal and Professional development

Mediation also typically involves reflection not just upon the dispute itself but also related issues that may have had a causal link to the dispute. Things such as record keeping, the handling of professional relationships and an awareness of the perspectives of others are matters that may be relevant to the dispute but are also of general relevance to a construction manager. Engaging with the process of mediation may allow the reflective professional to engage with many of these issues and may aid the development of important mental and social attitudes that create for mutually empowered and productive relationships. A widespread adoption of such values would subsequently contribute to wider cultural change.

Cultural change

Fostering behavioural change is one clear possible benefit of mediation. This should be considered as more than individual or organisational change. It should, instead, aim for the transformation of the culture of the industry as a whole. The value of co-operation and partnership in construction has been recognised by a number of authors (McDermott *et al,* 2005). With change occurring to the industry on many levels (Greed 1997) mediation might also have a formative role in this by fostering a collaborative approach to dispute resolution and professional practice generally. This approach might appeal particularly to women and other unrepresented groups (Gilligan 1998, Alberstein 2009).

7. Conclusion

Law and dispute resolution are typically conceived as being about achieving the 'right result'. There tends to be an assumption that 'justice' necessitates this. Mediation, though, works on a different paradigm:

> "In mediation, justice can be understood as the justice that the parties themselves experience, articulate, and embody in their resolution of dispute" (Rock, 2006, 347).

If this is accepted, at least in part, then this ought to open the gates to a consideration of mediation as a tool for development – individual professional development, organisational development and industry change. Construction education for one ought to consider this more fully. Finally, it can be argued that the habit of litigiousness which we have fallen in to has gone too far and that now there must be some appetite for achieving a wider cultural change away from conflict and towards a more co-operative form of human interaction. Construction professionals ought to realise that their profitability would be aided by this.

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Collaboration of industry and academia to develop online field training program

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Abstract

Multiple jobsites and geographic regions often make it difficult for industry to schedule training for employees. Another downfall is the expense of travel and time necessary to meet in one location. Online training via the internet has evolved and now provides real time collaboration between all participants no matter where they are located. This paper will describe the use of virtual training software to present synchronous distance learning program for construction field supervisors at a major university. Adobe Acrobat Connect Professional allows the faculty to use a hybrid synchronous, interactive delivery model for this certificate program. It allows the participant to be seen and to be heard, as well as to see and hear what is going on at the host site. The paper will outline the collaboration of development, the application of online technology, facilitation of curriculum, of the first online Construction Site Supervisor Training Certificate (CSSC) program.

Keywords: Online learning, field training, distance learning, virtual training

1. Introduction

The development of this program evolved over 3 years of an advisory board for an academic department, make up of industry professionals' collaborating with faculty. Reacting to the input from the Purdue University, College of Technology, Building Construction Management (BCM) department advisory board, faculty members developed an online certificate program for field personnel. Past training for field supervisors had been accomplished through grants paid by companies to faculty who would travel to the company to facilitate a training program. Due to the cost of travel, this would usually become a two day / sixteen hour training period where employees were paid to be at training and the faculty received payment for the travel, development, and facilitation costs. As the state of the economy remains marginal, it seemed that a new model needed to be developed. The following will outline the development of the program, the application of online interactive software, and the facilitation of the first online Construction Site Supervisor Training Certificate (CSSC) program at Purdue University.

2. Program Development

During the bi-yearly advisory meeting, minutes were recorded for the Field Supervisor training subcommittee break out session which demonstrated the needs and wants of industry. The process began in the Fall of 2007. The group reaffirmed its previous conclusion that there is a significant and continuing need for additional training programs and resources for field supervisors. Each of the companies represented in the task group discussed what they are currently doing to provide training for field supervisors. It was concluded that probably the most critical need is for "soft skills" and management training. Most companies are doing a reasonable job of providing basic technical training but typically do not have the resources to provide soft skills training. The need to utilize distance learning technology was also discussed, and it was agreed that using distance learning technology will probably be critical due to the fact that field supervisors are often on the move and are sometimes in relatively remote locations. The members of the group agreed to forward to the committee leader, the current expectations for each company and the competencies and training outlines that they currently have for field supervisors.

Data was collected to outline the topics for the training and the next meeting in Spring 2008 outlined the pros and cons of the training needs as it was reviewed by the group.

1) BCM Faculty develops customized training for company
   (1) Provided stand alone training, assessment and outcomes that can be given in the future by others
   (2) Will provide 1 year follow up with field to show Return on investment
   (3) Research / training grant as contract

Pros	Cons
* Company has own materials	* Travel for faculty ($$)
* Can be replicated by company later	* Non productive time of workers on projects

2) Continuing Education Units with online training
   (1) 1 – 2 hour sessions that companies or employees sign up for and take online
   (2) Face to face online with feedback
   (3) Could be cost per session or cost per company

3) Continuing Education Units with Webinars
   (1) 1 – 2 hour sessions with "talking head" not as much feedback
   (2) Could have price per company and multiple logins or group in one room

Online Education

Pros	and	Cons
* No competition / stay in home office		* Less customized
* No travel cost		* Technology training?
* Can be flexible with time Breakfast once / month & evening once per month		
***** Does not interrupt project productivity		

This meeting resulted in the action of developing an online teaching certificate program that would meet once a week for 10 weeks utilizing virtual training.

3. Types of virtual training

The first full online learning course was complete in 1981 (Harasim, 2000). As the internet has allowed for access, research has shown that online-learning enhances student learning (Brewer, DeJonge, & Stout, 2001, & Hoffmann, 2002). Distance learning is expanding in all areas of higher education to create more opportunities for students (Allen & Seaman, 2007). The first computer technology has expanded from the correspondence courses of the 19th century to live television courses and now online web-based versions (Monolescu, Schifter, & Greenwood, 2004). It is now possible for anyone to acquire education from anywhere in the world. Research exists that shows minimal differences in the effectiveness of online learning as compared to the brick and mortar / face-to-face traditional methods of teaching. The major needs for online programs have been shown to be convenience, access, and flexibility (Devi, 2001; Ryan, 2001). In construction management, persons currently working in industry cannot be away from their jobs due to responsibilities onsite.

Research was conducted by reviewing some of the existing online programs. One of the challenges of online learning is retaining the student; research has also shown that the dropout rate remains high (Connolly, MacArthur, Stansfield, & McLellan, 2007; Levy, 2007). It was important for developers to build a program that would align with student success. There are four major categories considered for online courses (a) self-paced, independent study, (b) asynchronous learning, (c) synchronous learning, and (d) a combination of online and in-person learning (Bocchi, Eastman, & Swift, 2004). Table 1 outlines the relationship of each instructional method with time, location and interaction:

Table 1: Instruction Methods Comparison

Instructional Method	Location	Time	Interaction
Traditional Learning	Faculty & Student in same place	Meet at same time	One on one and group interaction
Self-paced, independent study	Faculty & Student not in same place	Meet only as necessary	One on one interaction with teacher as necessary
Asynchronous Learning	Faculty & Student not in same place	Interact at different times	One on one interaction with teacher as necessary
Synchronous Learning	Faculty & Student not in same place	Meet at same time	One on one and group interaction

The online training program must provide the ability to complete course requirements with minimal interference of work. To minimize the costs related to travel and employee lost time on the jobsite, it was decided that the program needed to provide distance learning options.

The Adobe Connect Professional software tool, which was chosen for this training program, allows:

- Real Time interaction between faculty and class participants
- Interaction between all or part of the class participants
- No Travel to physical location of class
- Breakout Groups for small group discussions
- Polling ability to ask questions and display real time results
- Team Presentations where team members are at different locations
- Ability to record course discussions / lectures/ chat for review at later time or in case of missed class

4. Tools for teaching online

As early at 1916, curriculum theorists such as Dewey, believed that interaction was the defining moment of a student transforming knowledge into personal application and value (Dewey, 1916). The internet allows for this interaction to be accomplished in different methods. Figure 1 shows the relationship between interaction and the independence of time and distance.

Adobe Connect Professional is used for real-time meetings and seminars enriched with interactive presentations and discussion capabilities. It combines existing learning content with real-time interactivity between presenters and students for engaging collaborative teaching and learning experiences. Microsoft PowerPoint slides can be used to give a professional outline in real time, live and recorded video, Flash animations, live screen-sharing, audio, and two-way text chat to deliver more effective presentations. Adobe Presenter fully integrated with Microsoft PowerPoint that simplifies the creation and sharing of narrated, media-rich presentations. With Presenter dynamic presentations can be created to enhance training courses directly from within PowerPoint.

The Connect meeting room is a series of “pods” which can be moved and resized. Pods include camera and voice, polls, chat, attendee list, whiteboard, notes, discussion notes, share, file share and web links. A single room can actually have multiple screens with multiple pod layouts. Figure 2 shows the Camera and voice pod, presentation pod, attendees pod, and chat pod. The classes use a room with three layouts: presentation, discussion and collaboration. Each screen has its purpose. Most of the class work is done on the presentation screen. The discussion screen is used to facilitate classroom discussions. The collaboration screen includes a large whiteboard which the instructor can use like a chalkboard for drawing illustrations during class.

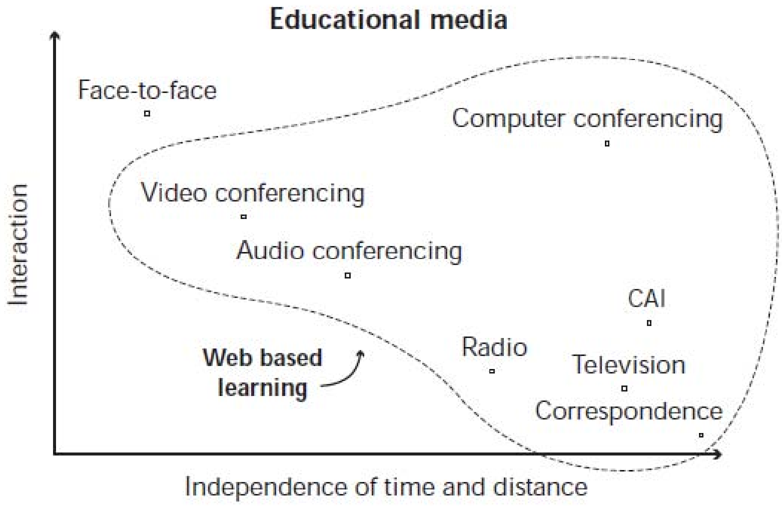

Figure 1: Relationship of Education Median with Interaction and Time and Distance (Anderson, 2004).

Managing the Connect classroom requires some multi-tasking by the professor. In addition to presenting a lecture with Microsoft PowerPoint, the instructor must also monitor the chat pod for student questions. While potentially daunting at first, this technique is not unlike monitoring the traditional classroom audience for raised hands.

Not only can the students attend class at home or at work, but the student can also attend classes while traveling. One faculty member was able to participate in classes while traveling in Costa Rica. Another advantage of Adobe Connect Professional for distance learning is that it is desktop-based. This means that using Adobe Flash Technology, the desktop (or laptop) computers are connected directly to each other. The software allows students and faculty to broadcast and receive live video and audio using broadband internet access, a computer, an inexpensive webcam, and a hands-free headset/microphone. In addition to the classroom meeting room website (URL), each student has his or her own room adobe connect site (URL) in the Connect system. These rooms are used for breakout sessions during class and for student collaboration on projects and meetings outside of class. These rooms are available to the students 24 hours a day, seven days a week.

Figure 2: Screen shot of Adobe Connect Professional Pod Layout Example

5. Implementation of Training

The program was developed into 10 modules and named the Construction Site Supervisor Certificate (CSSC). To overcome fear of technology, Module #1 was delivered live and in person on campus so participants could meet each other and establish relationships. Figure 3 shows some of the field supervisor students practicing with the technology in the university classroom.


Figure 3: Construction field student practice using Adobe Connect

The faculty demonstrated the software and hardware requirements for the class. Classes 2-10 were all facilitated in Adobe Connect Professional on Monday evenings at 5pm (EST). The initial CSSC group of participants was predominately from Texas, Indiana, and Illinois. The program was taught by three faculty members. Each course was assigned to a faculty member based on expertise and knowledge area. Adobe Connect allows for collaborative interaction as diagramed in Figure 4.

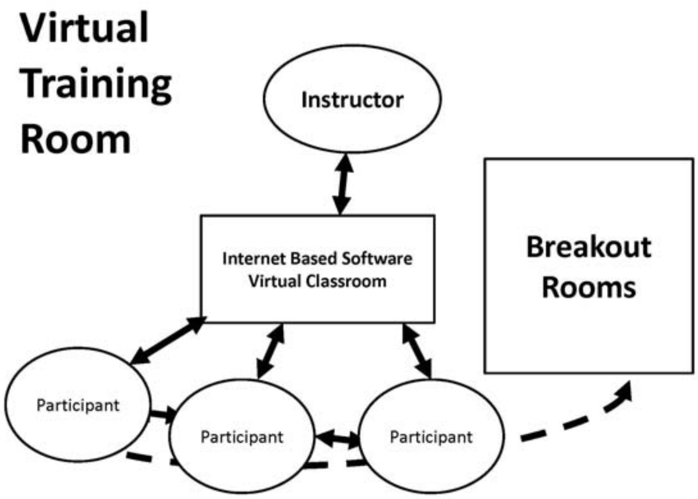

Figure 4: Virtual Training Room Schematic

There was initial skepticism by the participants as to the ability for a course to be taught in a Virtual Training Room. Many of the participants had less than 5 years of computer experience and were intimidated by the software. The initial on-site course put most concerns to rest when a simulation in the computer lab allowed them to see the ease and accessibility of the software. By the end of the second class participants were versed in using the system. Similar to in class training, students began to learn from one another. Each week participants were encouraged to share examples of job site situations that had happened and how they were handled. Participants became comfortable and active with sharing their ideas, photos, and examples via Adobe Connect during the class.

Upon completion of the modules, twenty of the twenty five students were able to attend the reception, dinner, and certificate ceremony. While the participants had only met in person once, they all greeted each other as old friends and peers. The ceremony allowed for verbal feedback and validation that the training was viewed as successful.

6. Conclusions

This is a simple model for implementing an affordable field supervisor training program. It not only has flexibility to align with the needs of the construction industry, but also retains the rigor of academic standards with high level faculty. The Adobe Connect Professional technology is easy to learn for instructors and for participants. Although evaluations were small from the first cohort, improvements have been put into place to assist in the success of the next groups. This program should be taken into consideration for other programs needing to accommodate industry training at any level. Future plans also include the evaluation of the overall program using pre and post test data connected to knowledge and confidence. A second group of students began in January 2012 and more continuous improvement will occur as this group evolves.

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Consumption of human resources in construction projects: a value adding perspective

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Abstract

The main purpose of this paper is to contribute to the debate on productivity improvements by providing a diagram presenting consumption of human resources, i.e. people's time, over a project cycle starting at the initial discussions in the client organization and ending six months after delivery. Data on consumed resources is gathered from the client and participating designers and contractors, but also from contractors submitting unsuccessful tenders and from local authorities. Information on what is considered value added time, indirect value added time and non-value added time is added to the diagram. The evaluation of whether the consumed time is value adding or not is based on interviews with client's project manager and on experiences from previous studies. The diagram inspires to several questions of relevance for further studies. For example, are the local authorities' processes coordinated with construction projects' processes?

Keywords: construction process, resource consumption, waste, value adding activities, Scandinavia

1. Introduction

There is a continuously ongoing debate concerning productivity improvement and costs for construction in Sweden. Statistics showing how prices have developed over time indicate that the costs for producing buildings have increased strongly. Figure 1 shows how the price index for multi-family housing has developed since 1994 compared to consumer price index for the same period. These statistics, or rather the way to use the statistics, have been questioned for not considering market changes and changes of qualities in products.

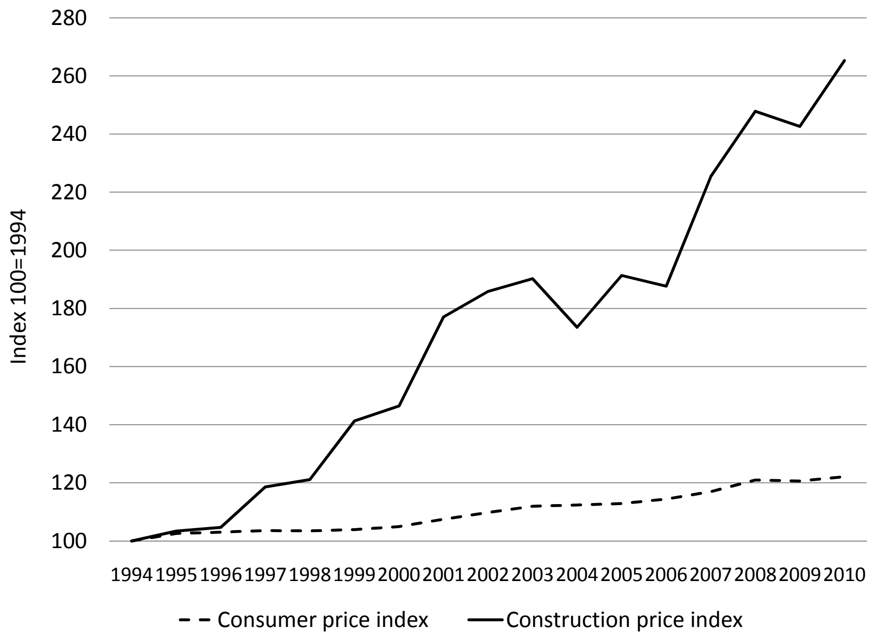

Figure 1: Construction price index (1994=100) for multi-family housing 1994-2010 (Data from Statistics Sweden, 2011-12-14) and consumer price index (1994=100) (Data from Statistics Sweden, 2012-02-16).

Data from National Institute of Economic Research (2012-03-08) show how productivity improvement is slow in construction compared to many other industries, see Figure 2. These conclusions are questioned by practitioners within construction and also by Lind and Song (2012) who found several peculiarities in how the data are collected and used, for example on how qualities in buildings are evaluated each year.

A problem with using costs and prices as a measure for productivity development is that resources are valued differently depending on market situations where the resources are consumed. This paper takes another angle by focusing on time, firstly, resource consumption in terms of hours spent by human beings directly involved in the project and, secondly, lead-times. The main purpose is to contribute to the debate on productivity improvements by providing a time-human resources-diagram over a building project starting at the initial discussions in the client organization and ending six months after delivery. The paper presents preliminary results from an analysis of a five-storey office building in

Gothenburg. The study is a part of an ongoing work of discovering “hidden” processes in construction processes.

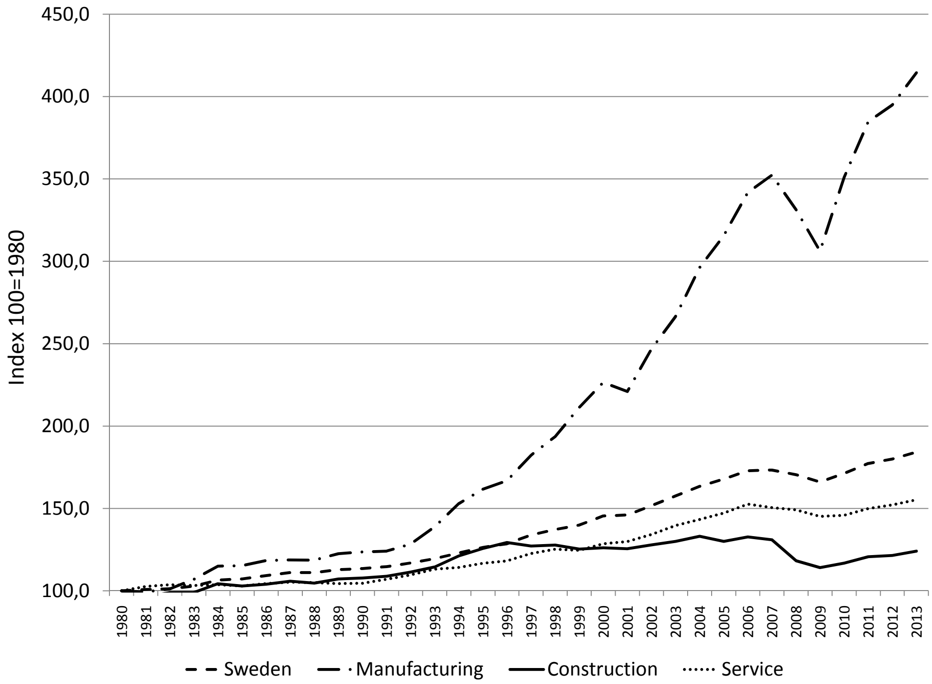

Figure 2: Productivity index (1998=100) for Sweden, manufacturing industry, construction industry and service industries 1980-2013 (Data from National Institute of Economic Research, 2012-03-08.)

2. Value adding or non value adding?

Non value adding activities are defined by Hixon (1995) as “anything that can be eliminated without detriment to the final product or service” and by Formoso et al (1999) as “any losses produced by activities that generate direct or indirect costs but do not add any value to the product from the point of view of the client”. The concept of non value adding has certain similarities with how the term waste is used in the lean philosophy. A common definition of waste is “any activity, which absorbs resources but creates no value” (see e.g. Womack and Jones, 1996). The concept has also similarities with the concept of costs for poor quality.

In real situations activities can be viewed as value-adding by one actor but as non value adding by another. Of that reason it is generally argued that it should be a clear focus on the customer in order to determine what is not adding value, what is waste and what is costs for poor quality. A challenge is, however, to define who the customer really is. In this paper, the client organization is viewed as customer even if they have tenants using the building as their customers.

All types of activities can be described in terms of processes. Processes are usually divided into three categories. Operative processes are series of activities (work elements) that directly add value in the viewpoint of the customer. If an activity that is a part of the operative process is taken away, the product or service will be incomplete. Support processes are activities or series of activities that support the operative process. They do not themselves add value to the product or service but are necessary for the operative process to function. Management processes are activities or series of activities whose purpose is to determine the organisation's goals and strategies. Non value adding activities exists in all these categories of processes. In the operative process, the activities can perhaps be carried out in another order and in this way free up time or the activities may include corrections of defects. In support processes and management processes, there may be routines that added value at one time but have now lost their purpose.

Problems can arise in determining whether support and management processes should or should not be classified as non value adding. For this reason we divide work in value-adding work, indirect value-adding work and non value-adding work. Indirect value adding work refers to processes that are necessary for the value-adding work to be carried out.

3. Method

3.1 Collecting data on time consumed

Data was collected in two phases. In 2009, one of the authors collected data for the period January 2008 to October 2009, which covered the brief and design phases (see Christiansen, 2010). That study was designed in order to extract the client's assessment of the resources consumed throughout the period. In 2012, the two authors made up the study by collecting data on the initial discussions during 2007 and for the period November 2009 to January 2012 that included the final part of the design phase, the construction work on site and additional work during the first six months of use. During the second phase data was also collected from contractors not winning contracts.

Interviews in the first phase of data collection were held with the client, the contractor and the city planning office to gain an increased understanding of their roles in the project. As the city planning office included many sub organizations, each of the following were interviewed once: the surveyor, the plan architect and the building permit administrator, all assigned to the project. To construct a timeline of past events documents produced, acquired and received by the interviewed organizations were studied. These documents included invoices received by the client, minutes from meetings held by the project steering committee, a diary for the registration of property, records of the hours allotted to the project by the plan architect and the contractor and a copy of the granted building permit. With these documents and interviews it was possible to map the use of resources throughout the studied phases of the project.

In the second phase of the study data was collected by studying invoices to the client and to the main contractor, minutes from sub-contractor-meetings held by the site manager on site. Data was also received directly from the client, an external project manager, a couple of designers, the main contractor, contractors not winning the contract and a couple of sub-contractors. Interviews were also held with the client's internal project manager for the latter stages, one of the external project managers and the site manager. The volume of time spent by contractors' suppliers in the tendering phase was estimated based on the number of firms contacted by winning contractor and previous studies done in the research group (see Josephson and Saukkoriipi, 2005).

With these documents and interviews it was possible to map the use of resources throughout the studied phases of the project. When data was given for a full week or month, daily averages, based on the period of data, of the hours consumed by each resource where calculated. Descriptions of the kind of services acquired by the client were added based on the interviews and literature.

The volume of time is underrated. Among the resources consumed but not included in the study is time spent outside the construction site for manufacturing and transporting components to the site, time spent by various authorities, time spent by administrators and middle and top managers within participating firms to support their employees and time spent by individuals or firms that participated for very short periods or only spent a few hours in the project.

3.2 Assessing the value added

After the resources consumed were mapped in the first part of the study, a client representative was asked to assess the extent of each resource's contribution to the project. Since time served as a basis for this assessment, the representative could focus strictly on the contribution made by each resource without taking its associated cost into account. The evaluation took place during interviews in which the representative was instructed to also further elucidate the kind of contribution each resource made. The assessment was based on the premise that all value created throughout the studied phases could be found in the qualities, that was the designed features and attributes, of the building. Therefore, there was no definite amount of value assigned to neither the building as a whole nor any specific attribute or feature of it. By doing so the study was also able to circumvent the argument by Thomson et al. (2003) that clients are incapable of evaluating a building prior to its completion. Time that was consumed by a resource producing a feature or attribute that at the time of the study could be found in the design of the building was categorised as value adding. Time that was consumed by a resource to make the project feasible, however, without producing a feature or attribute that at the time of the study could be found in the design of the building was categorised as indirect value adding. Allocated to this category was time consumed to either enable a subsequent step, to comply with requirements by authorities, to enable the use of current methods, to bring the design of the building forward without being a part of it or time that could not have been removed without having affected the perceived value acquired by the client. Time that was consumed by a resource without affecting the project was categorised as non value adding. The result of the consumed resources belonging to this category either came to be scrapped or re-worked.

The second phase of the study mainly covered resources consumed by contractors during tendering and on the construction site. For tendering, all work done by contractors as well as by their possible suppliers not winning a contract was categorised as non value adding even if competition lead to lower bids and following this an increased demand for the winners to be resource efficient during production work. For the rest of the contractors work, estimations were done based on previous studies in the research group. Contractors' workers time was divided based on Strandberg and Josephson (2005), who found that 17.5% of the time was value adding, 45% indirect value adding and

37.5% not value adding. Subcontractors workers time was based on Josephson and Björkman (2010), who found that roughly 15% of the time was value adding, 50% indirect value adding and 35% not value adding. The contractors' and the sub-contractor's managers time was considered as indirect value adding or not value adding. Based on discussions with a group of contractors the time was equally divided between indirect value adding and not value adding, since much time is spent on taking care of problems.

In the second phase of the study, the client's internal project manager for the latter stages and one of the external project managers were also asked to evaluate when decisions were made about the features and attributes in the product and how much it influenced the final product.

4. Case: Kuggen

4.1 The product

The case project is a new production of a five-storey office building on one of the two Chalmers campus areas in Gothenburg. The most striking with the building is the circular form, the bright colours and that each storey is designed as cog-wheels lying down, Figure 3. The form has given the building the name Kuggen (English: the Cog). Five such cog-wheels are placed on top of each other, but each storey has two more cogs than the one below. In that way the building becomes wider for each storey. By shifting each storey in southly direction, upper storeys shade the lower ones and influence the inner climate. A mobile screen, moving as the sun is moving, shade the upper storeys. The windows are triangular with the widest part on the top to give sun light far into the building. A goal was to minimize the energy use. Estimations give that the energy use is appr. 55 kWh/m² and year. In total the building has 188 cogs, each representing an office module. The total area of the building is 5350m^2. The project cost is SEK 135 million (roughly €15 million).

4.2 The process

The idea began during the autumn 2007 in a discussion between Chalmers University of Technology, Lindholmen Science Park, Chalmersfastigheter (the client) and Älvstranden Utveckling (wholly-owned municipal company, commissioned by the city of Gothenburg to lead the development of the area of which the campus area is part of) about how the Lindholmen campus and the areas close by could be further developed. The discussion led to an insight that collaboration is a main reason for the university as well as numbers of private companies and other organizations to set up businesses in the area. However, meeting places were missing. The idea of a building that could generate meetings and connect individuals as well as organizations came up. One goal with the project was to create a building that stand out and could be a symbol for Chalmers, Lindholmen and the city. Already from the start it was obvious that designers and contractors were willing to invest more than normal to win a contract.

Figure 3: Kuggen (Photo: Tobias Hildorzon, Peab)

In January 2008, an architect and a project manager was hired, followed in February by a structural engineer and in March by a heating, ventilation and plumbing consultant and an electrical engineer. During an interview the client described how the architect had been given the mission to design a building “that was about 4000 m^2, would connect two adjacent buildings and have a striking design”. That several conceptual suggestions were produced prior to the brief ending at March 31 greatly affected the client’s assessment of the work conducted as only20% was considered directly value adding, the remaining 80% was considered non value adding. The 20% represented the client’s assessment of the time spent by the architect producing the conceptual suggestion that came to be adopted. On February 8 the client applied for a change in the municipal detailed development plan as the site on which the building was to be constructed was a public square.

During the two subsequent months a soil mechanics engineer, an acoustician, a telecommunications consultant and an environmental consultant was added to the project group that were occupied with a first, simplified, version of schematic design finalised on May 31 2008. Initially the soil mechanics engineer relied on previously available information, but as this proved to be unreliable once drilling began, a large quantity of work came to be scrapped. This was reflected in the client’s assessment of the time spent as 50% was considered to have been indirectly value adding and 50% was considered to not have been value adding. A large part of the work functioned as the basis for design of the foundation. However, as no suggestions were made from the soil mechanics engineer the client did not regard the efforts as value adding.

Approaching summer the extent of the project teams’ engagement was reduced until the end of July where it picked up again as efforts to develop a deepened schematic design were increased (see Figure 4). This deepened schematic design also formed the basis for tender documents received by contractors on September 26. The procurement was subject to the Swedish Public Procurement Act and an open-competitive tendering process was chosen by the client. There were six contractors that supplied tenders, whereof four invested more time than normal for a contract of this size. Tender documents were due to the client on November 27. In total only 2,5% of the time spent by the winning contractor during this tendering period was considered to have been directly value adding, this in turn represented 75% of the time the structural engineer hired by the contractor spent on developing an alternative tender that later came to be adopted by the client. 25% of the time was estimated to have been indirectly value adding and 72,5% was considered not value adding. All work done by contractors not winning contracts was categorised as non value adding.

Tender documents were examined, processed and balanced by the client aided by the project manager throughout January and February 2009. However, once the client had awarded a contractor the contract the project was efficiently put to halt until late April as a competing contractor appealed the awarding process. This greatly affected the clients' assessment of the work conducted by the hired project manager. During March and April 90% of the time spent was considered as not having added value. The remaining 10% was considered to have been indirectly value adding.

On January 16 the client had applied for a cadastral procedure to secure future construction. However, as the building being designed was to connect two adjacent buildings through footbridges it required for the cadastral procedure to include three-dimensional spaces which prolonged the procedure. The detailed development plan enabling the future construction works gained legal force on July 22 2009. The client regarded no part of the detailed development planning process as value adding, despite the fact that it was required by the law. The cadastral procedure was approved and registered by the city planning office on September 17 2009.

The project team gained momentum once again as July came to an end and the third deepened schematic design was produced in collaboration with the awarded contractor. The goal was to find alternative solutions that were cheaper, but also more in line with the client's vision concerning sustainability.

The construction work on site began in November 2009 with foundation work. Work on the loadbearing structure began in March 2010, while work on the framework supplement work began in September 2010. At that time sub-contractors for electricity, plumbing, ventilation etc joined the organization. Final inspection was held May 6 2011. The process related to production and production planning is presented in detail by Christiansen (2012).

Total number of hours consumed in the project (collected so far) was 152 854 until January 2012. The client organization, including external project management consumed almost 11 000 hours, designers more than 16 000 hours and contractors over 125 000 hours, see Table 1. The total work by contractors on tendering work was 12 400 hours or almost 10% of their time. Compiling the assessments reveals that 11.7% of the consumed resources are regarded as having directly added value, 43.5% was seen as indirectly having added value and the remaining 44.8% was considered as not having been value adding. In Figure 4 it's presented how the resources are consumed over the project cycle starting in the idea phase (November 2007) and ending six months after delivery (January 2012). Figure 5 presents accumulated resource consumption over the project cycle.

Table 1: Human resources (time) spent on the project.

Group of actors	*Time (hours)*	*Percentage (%)*
Client's internal and external project management, authorities	*10 936*	*7,1*
Designers	*16 163*	*10,6*
Contractors	*125 755*	*82,3*
Total	*152 854*	*100,0*

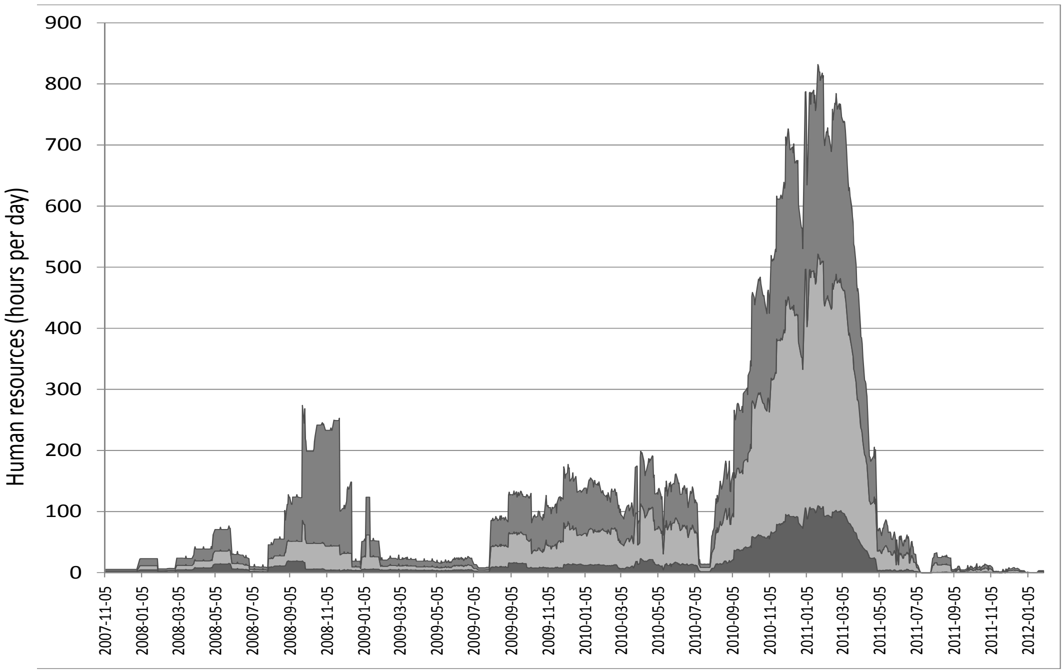

Figure 4: Resource consumption over time categorized in value adding (dark grey), indirect value adding (light grey) and non value adding (grey).

4.3 Possibilities to influence the product

The client's internal project manager for the latter phase of the project and one of their external project managers evaluated when decisions were made for the product and how much the form and characteristics were locked. They agreed on four identified occasions of relevance. First, nothing was really fixed until the form of a cog was decided in March 2008. That decision greatly affected the following work, so they thought that 60% was locked at that time, see Figure 5. Second, the decision to slightly move each storey compared to the lower one fixed the product for another 20%. Third, another 10% was fixed during the design autumn 2009. Fourth, the last 10% was fixed during the production planning and production work on site. After that no real influence on the product.

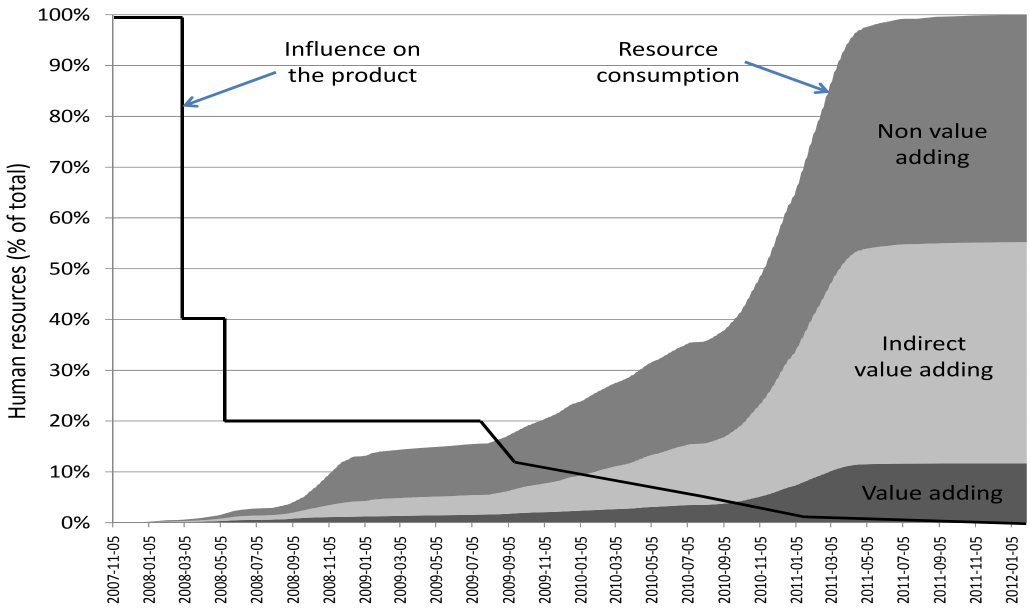

Figure 5: Resource consumption accumulated over time and possibilities to influence on the product.

5. Discussion and conclusion

The aim of the paper has been to contribute to the debate on productivity improvements by providing a time-human resources-diagram over a building project starting at the initial discussions in the client organization and ending six months after delivery. The aim is not to criticize construction, rather to increase the understanding of how human resources are used in complex construction projects.

All work hours identified is categorized in value adding, indirect value adding and non value adding work. The amount of value adding time could be viewed as surprisingly low. But again, this is just a way to describe work. The ideal way forward could of course be to decrease non value adding time. On the other hand, it is often the case that productivity improvements lead to less value adding work measured in number of hours spent by humans and increased indirect value adding work as well as increased non value adding work. There are also local conditions to consider. One example is the increased attention on safety and environmental issues, which over the years has increased the time spent on preventive work significantly. That means an increase in indirect value adding work. A result is, however, less time on non value adding time caused by safety and environmental incidents. Another condition of relevance is the fact that the project was prestigious to be part of. At least four of the six contractors that competed for the contract invested more than usual for a contract of this size. One of the managers for the winning contractor, who had more than 20 years of experience, explained that “I’ve never experienced that we have spent so much time to win a contract of this size before”.

The evaluation of resources consumed by the client organisation and designers was done by a client representative during the process. In line with Bowman and Ambrosini (2000) value was considered to be created if the consumed resources result in a feature or attribute of the design, however, the final assessment does not take place until the client receives the finished facility. Up to that point it remains uncertain whether or not the client perceives it as use value or not. Despite the fact that the project went through several incidents that caused extra time and delayed the process, it is perceived as successful. Both the university, which is owner of the client organization, and the building contractor use Kuggen as an example of a successful project.

Not all resources consumed on behalf of the project have been included in the study which constitutes a limitation. Those excluded are the manufacturers and transporters of components, the building permit administrators, the lawyers engaged in the appeal and numbers of organizations that consumed few resources in the project.

The diagram presenting the consumption of human resources does, however, inspire to several questions of relevance for further studies. For example, are the local authorities' processes coordinated with construction projects' processes? What would renewed ways of working by the client as well as by the local authorities involve? To what extent do each actor, i.e. local authorities, client, designers and contractors, influence the volume of resource consumption and when the resources are consumed?

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The salience of national culture in influencing individuals' HRM preferences and construction firms' HRM practices

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Abstract

Human resource management (HRM), if it is practiced at all in the construction industry, is mostly done in an ad-hoc, sporadic way. This has contributed to criticisms that the industry is lagging behind others in effectively recruiting and retaining scarce talents. Construction management researchers have long argued for the benefits of construction firms adopting a more integrated and strategic approach to HRM. However, the HRM model that is being promoted within much of CM literature is based largely on the US/Harvard model. It appears that the default assumption of this model ignores the salience of national culture in determining HRM effectiveness. This paper discusses the results of an empirical study of 604 construction professionals from Australia and Hong Kong to analyse the extent to which differences based on national culture influence individuals' HRM preferences on remuneration and job autonomy, and whether these preferences have a bearing on the actual types of organizational HRM practices that are being adopted. The results indicated that national culture is a salient factor that affects HRM preferences and effectiveness. Implications of this for future HRM research, education and practice within the construction industry are offered.

Keywords: Human resource management, national culture, construction management.

1. Introduction

Skills shortage is a long-standing problem for the construction industry. Particularly challenging for many firms is the difficulty of attracting, recruiting scarce talents and, subsequently retaining them, as the industry continues to have one of the highest turnover rate of all major industries. In the UK, The Chartered Institute of Building (CIOB) has been conducting yearly surveys since 2006 on the extent and implications of the skills shortages problem. It recently reported that "the construction industry continues to suffer from a skills shortage, despite an overall decrease in construction demand in 2009 by 11.5%" (CIOB, 2010, p.2). This has reinforced the commonly held view that the construction industry is, i) simply not attractive enough to potential recruits; ii) it is not doing enough to attract them; iii) it fails to retain them. To this end, many CM researchers and industry practitioners have long-argued that the effective use and adoption of human resource management (HRM) practices can to a large degree ameliorate the situation through better approaches to recruitment, remuneration, and training and development (Chan and Dainty, 2007; Dainty et al., 2000; Loosemore et al., 2003; Drucker and White 1996, Langford et al., 1995).

Notwithstanding the cyclical boom-bust periods and broader structural factors that contribute to the construction industry's skills shortage problem, the "dominant culture [which] consistently emphasises the hard model of HRM..…goes some way towards explaining the current recruitment crisis" (Green, 2002, p.148). Instead of traditionally emphasizing on the importance of a 'hard' strategic management approach to human resources which are operationalized and measured by performance-based indicators against various organizational objectives, researchers and practitioners are urged to incorporate into their HRM practices 'soft' human relations aspects which rest on commitment, trust, empowerment, self-fulfilment and individual development. This essentially US/Harvard-inspired HRM model with both its hard and soft elements (Beer, et al. 1984, 1985) has since the 1980s merged into a unified HRM model (Morris et al., 2000) where a 'people-centred' approach is becoming more widespread in contemporary strategic and organizational management.

Central to the utility of the US/Harvard model is the emergence of HRM as a business strategy which crystallised the view that firms ought to define their HRM objectives (i.e. who and how to recruit and train, what remuneration, appraisal systems to adopt) in order that these align with broader organizational goals (Brewster, 2007; Fombrun et al. 1984). This reinforces what Becker and Gerhart (1996, p. 781) have long ago suggested that for HRM to create strategic impact it requires "a degree of attention to alignments both within HR systems (internal fit) and with operating and strategic objectives (external fit)". This approach of adopting strategic, measurable performance-based HRM practices and combining them with 'softer' aspects of HRM that align with firms' overall business strategy is regarded as the way forward for industrial practices, including for the construction industry (see Drucker et al., 1996; Loosemore et al., 2003). Moreover, the US/Harvard HRM model is deemed universally applicable even for businesses that are established outside the US (Kidger, 1991) because it is argued that certain values and practices are convergent and shared globally regardless of firms' corporate strategy (Beer et al. 1984). Indeed, there is growing evidence of the convergence of HRM practices in some areas such as recruitment and performance-based remuneration even in traditionally collectivistic countries like India and China brought about by globalization (Budhwar and Bhatnagar, 2009; Warner, 2003).

2. Evidence of non-convergence of HRM practices

However, as the field of management matures many researchers have started to evaluate the notion of the universally applicable US/Harvard HRM model. In particular, the level of convergence of HRM practices in international settings omits considerations for national cultural nuances as well as other institutional, and even firm-level differences that are at play which have an impact of HRM effectiveness (e.g. Gamble, 2003). Research in mainstream and international HRM indicates that the effectiveness of HRM practices is culture specific (Brewster, 2007; Sparrow et al, 1994; Tregaskis, 1997; Budhwar and Khatri, 2001). This means that individuals with different cultural values have different preferences for HRM practices such that organisations must adapt their HRM practices to meet the local cultural norms (Ramamoorthy et al, 2005). Empirical evidence shows that organizational HRM practices that closely fit the broad societal values that individuals intrinsically relate to tend to lead to positive job attitudes and better job satisfaction (Brewster, 2007; Ramamoorthy et al, 2005). These in turn, tend to translate into improved organizational outcomes through better employee recruitment and retention.

More broadly, Brewster (1999; 2005) has argued that because of its cultural, institutional and political landscape HRM is conceptualised and practiced differently in Europe compared to the US. More recently, Brewster (2007) provided evidence that the main discernible HRM differences in Europe compared to the US are its less individualistic and achievement-oriented culture; the stronger role of the state that leads to highly legislated employment frameworks; the much stronger influence of trade unions on employer-employee relationship; and the ostensible favouring of public business ownership rather than private sector ownership with stock-market trading shareholders. In another example, Brewster et al. (2006) showed that cross-cultural differences between Europe and Japan are important determinants of the size and role of HRM in these respective organizations. Similarly, Ramamoorthy and Carroll (1998) have empirically shown that depending on its national cultural norms, employee preferences for HRM practices differ such that individualistic countries like the US, UK and Australia would tend to promote individualistic HRM practices that emphasise more on competitiveness, equity and individual achievements compared to more collectivistic societies like India and China.

3. HRM research in construction management

The above discussion offers compelling evidence of the moderating effects of cultural norms on HRM preferences and practices in different national contexts. While studies have found that distinct individual values, attitudes and behaviour that are based on deep-seated cultural norms have direct implications on HRM practices, there remains relatively little empirical research done to examine the level of *divergence* of HRM practices in different countries (Tung and Baumann, 2009). Even much less research of this kind has been undertaken in the construction industry.

Although construction researchers have alluded to the need to be cognisant of the moderating effects of certain industry-level characteristics in determining the effectiveness of HRM practices (e.g. Green, 2002; Phua, 2004), no empirical studies specifically on the effects of national cultural differences on HRM practices has been conducted. It seems that many practitioners and researchers intuitively know that culturally-based variations in HRM practices exist, but the extent and nature of the variation has never been explored more deeply. By and large, construction management books and articles on the subject of HRM still subscribe to the merits of adopting a strategic approach to HRM which mirrors the US/Harvard-based model of combining hard and soft HRM practices that align with the overarching organizational goals. Unfortunately, the research inquiry into HRM ends there. It appears that the default position of convergence of HRM practices is assumed to exist across the construction industry. This has contributed to a situation which (intentionally or unintentionally) downplays the need to investigate the nuanced cultural differences and characteristics of HRM practices that might occur in different countries or settings. Given the size and importance of the industry in the global economy and its ongoing endeavours to address the persistent problems of skills scarcity and high turnover rate, there are strong practical, economic and scholarly grounds for a more sophisticated, fine-grained understanding of the nature of HRM practices in construction than has hitherto been the case. If the industry is to find effective ways to overcome its skills shortage problems, it needs to understand the extent to which the broadly accepted HRM practices as they are being advocated by academics, and taught to students and practitioners are influenced by national cultural differences.

4. Culturally nuanced HRM research in construction management

4.1. Study context

This paper discusses findings from a study of 604 construction professionals from Hong Kong and Australia to determine firstly, if differences in individual preferences toward a variety of HRM practices exist in countries known to have distinct national cultural characteristics. Second, if such differences exist, to what extent do construction firms adopt HRM practices that reflect these differences? Third, does the gap between individuals' preferences and actual organizational HRM practices affect individuals' job satisfaction – the widely used proxy in organizational research to determine employee retention and turnover rate (see Whitman et al., 2010)? It is also a reliable indication of the effectiveness of HRM practices that are being adopted by firms. The cultural distinctness between Australia and Hong Kong (Hofstede, 2001) is such that Australia is still commonly regarded as a strongly individualistic country while Hong Kong is conventionally characterised as a collectivistic society. There are practical reasons too, for choosing Australia and Hong Kong as a basis for comparison. In both cases, the construction industry is one of the largest industries directly employing about 10 per cent of the working population (ABS, CSD), implying that the issue of professional skills shortages is likely to be felt more strongly than in countries where the industry is smaller.

In this study, the two key HRM practices selected for testing and analysis relate specifically to remuneration and job autonomy because both are commonly employed by HRM researchers interested in the types of reward and job design practices of firms (Ramamoorthy and Flood, 2002, Ramamoorthy et al, 2005). Specifically, it is hypothesized that Australian professionals, with individualist orientations have stronger preferences for individualist HRM practices that emphasizes on meritocracy in terms of remuneration which promotes more competition, individual achievements and individual incentive schemes (Ramamoorthy and Flood, 2002; Ramomoorthy and Carroll, 1998). In terms of job design, professionals with individualist orientations tend to prefer higher levels of job autonomy where the freedom to be left alone to get on with ones' work and to take initiatives such as goal settings or decision making are valued. Conversely, with collectivist cultures collectivist HRM practices are preferred and in this regard, group-based rewards and less job autonomy are the norm. Because of these differences in individual HRM preferences, it is further hypothesized that firms operating in Australia (i.e. individualist society) will adopt and implement individualist HRM practices that correspond to the prevailing cultural norms, while firms in Hong Kong (i.e. collectivist society) will likewise have more collectivist HRM practices to reflect the dominant cultural norms. Finally, it is hypothesized that a good fit between individuals' HRM preference and actual organizational HRM practices is likely to lead to increased job satisfaction.

A survey questionnaire was initially mailed to 3,000 construction professionals, half from Hong Kong and another half from Australia. A quantitative approach is chosen deliberately for a large cross-sectional study like this in order to achieve the required statistical integrity and robustness that are necessary for the generalizability of results. The sample was derived from various professional association membership directories. After two mailings, and eliminating incompletely filled instruments, a total of 604 responses were obtained, 353 from Australia, 251 from Hong Kong. A series of statistical checks were performed to ensure a representative sample was obtained. In terms of nationality and cultural background of the respondents, 84.7% of respondents from Australia described themselves as 'Anglo-Celtic Australian' while 84.9% of respondents from Hong Kong described themselves as 'Hong Kong Chinese' confirming that the vast majority of respondents are indeed native to Australia and Hong Kong, hence providing the overall sample with the required cultural distinctions. In terms of language difficulties that might be present in the Hong Kong subsample in completing the questionnaire, this is deemed very unlikely to be an issue because all the respondents were construction professionals holding either senior or middle management positions, and furthermore English is still the lingua franca and official business language there.

Measures for individual HRM preferences and actual firm HRM practices on remuneration and job autonomy were based on existing scales that have been widely validated in other HRM studies (see Ramamoorthy and Carroll, 1998 and Sims et al., 1976). Similarly for job satisfaction, a widely used, pre-existing scale based on Price and Mueller (1981) is used in this study.

4.2. Discussion of study results

The results of this study show that national cultural differences significantly influence individuals' HRM preferences. Not only do Australian construction professionals prefer more individual-based remuneration, they also prefer higher job autonomy when compared to their Hong Kong counterparts. These results echo previous research showing that individuals' cultural orientations are significant factors that influence their reactions and preferences to different HRM practices (e.g. Kirkman and Shapiro, 1997; Probst and Lawler, 2006). Even in the context of the construction industry, where it is common for construction professionals to work in international project teams and coalitions, there are reasons to believe that the prevailing cultural norms that they possess are not likely to be eroded in these work circumstances. This is supported by Tung and Baumann's (2009) research which revealed that Chinese and Caucasians show inherently distinct attitudes toward various HRM-related issues "regardless of whether the Chinese live in Mainland China or whether they were born, raised and resided overseas" and that their "attitudes have not assimilated to the culture of their country of birth and residency; but rather are closer to those of the country of origin of their ancestors" (p.2396). This gives added credence to the findings in this study that the differences found in individual HRM preferences stem from the core differences in cultural norms and values between Hong Kong and Australian respondents.

This study also revealed that firms are cognizant of the prevailing cultural distinctions and are adopting HRM practices that align with and support these cultural norms and values. Indeed, Australian construction firms adopt a more individualist approach to remuneration and job autonomy than Hong Kong firms. This is an important point to note because if individuals' cultural preferences are not supported by the appropriate organizational practices, job dissatisfaction and other negative job attitudes will ensue which will consequently undermine firms' ability to recruit talents and retain their employees. This view is reinforced by the results of this study showing job satisfaction is significantly correlated with the extent of fit between individuals' HRM preferences and actual organizational HRM practices. This finding is perhaps a preliminary indication that the low retention or high turnover rate in the construction industry could be better addressed if consistently better fit exists between individuals' HRM preferences and actual organizational practices.

5. Implications of an *acultural* HRM literature for CM research and practice

Taken together, the results from this and other previous studies in mainstream management indicate the salience of culture in influencing individual HRM preferences and also the extent to which these preferences are reflected in firms' HRM practices. What this implies is that contrary to the *acultural* view of HRM that dominates much of CM literature, there are in fact discernible culturally-based variations in the ways construction companies practice HRM and enact HRM-related policies. Although some might argue that these findings are not entirely unexpected, it is noteworthy that this body of knowledge does not yet form part of the CM literature in a conceptually meaningful way. It is these varied HRM practices that need to be robustly incorporated into the CM literature to facilitate a more sophisticated, fine-grained analysis of HRM and its characteristics. More importantly, the study results highlight the (non)efficacy within the field of construction management of adopting a generic US/Harvard-derived HRM model which largely ignores the influences cultural nuances. An uncritical CM literature in this context not only hinders theory development but also weakens considerably the research-practice nexus which arguably contributes to construction firms being poorly positioned and ill-informed to attract, recruit, and retain scarce talents.

A good starting point perhaps, for a 'new paradigm' for resolving the UK construction skills crisis (Chan and Dainty, 2007), would be for the research community to adopt a more critical and sophisticated perspective on HRM to examine the subtler linkages and the cause-effect relationships between different contextual variables at the country-, industry-, firm-, project-level that have hitherto been missing. The knowledge and understanding that stems from more fine-grained research inquiry should lead to tangible, rigorous and coordinated improvements in the ways firms practice HRM instead of the largely ad-hoc, piecemeal approach that they seem to be doing all along. A useful way toward a more robust and critical literature is for both industry practitioners and researchers to shift their current focus from identifying the factors that contribute to the industry lagging behind others in HRM successes (such as project-based environment, temporary-multi-organizations, prevalence of subcontracting) to *why* and *how* these very factors affect the success or failure of HRM in construction.

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The Effects of Compliance, Identification and Internalization on Conflict Management Styles

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Abstract

Disputes and conflicts are common in construction projects. Researchers have studied five different styles to handling conflicts: integrating, obliging, dominating, avoiding, and compromising. However, negotiating with different conflict management style may result in quite different outcomes. Some people seem to be very considerate, but do not really honor the promise. However, some individuals may appear to be very strong and tough, but once an agreement is reached, they will conform. Conflict management is a form of social influence among individuals. The outcomes of the conflict management are not only integrated into their own value system but highly dependent on the external social support system. In this context, three processes of social influence were distinguished--compliance, identification, and internalization. Thus this study explored the relationship between the three social influence processes and five styles of handling conflict. It is found that "Internalization" contributes to the conflict management styles of "Compromising" and "Integrating", "Identification" drives "Dominating" style and "Compliance" nurtures "Avoiding" and "Obliging" styles. The findings also indicate that rules, roles, and values are the three central components for individuals and groups negotiating in social environment. Negotiators must coordinate their actions with the counterpart respecting the rules, performing their roles and maximizing their values.

Keywords: Conflict Management Style, Compliance, Identification, Internalization, Negotiation

1. Introduction

Disputes and conflicts are common in construction projects. Conflict is defined as an " interactive process manifested in incompatibility, disagreement, or dissonance within or between social entities" (Rahim, 1992, p.16). Researchers have studied five different approaches to handling conflicts (Blake and Mouton, 1984; Thomas, 1976). Rahim (1983) has classified conflict management styles as integrating, obliging, dominating, avoiding, and compromising. Since then, a growing body of research on conflict management style reflected the immense interest of the dispute resolution community (Ting-Toomey et al., 1991; Rahim and Magner, 1995; Antonioni, 1998; Munduate et al., 1999; Gross and Guerrero, 2000; Cai and Fink, 2002). It is well recognised that negotiating with different conflict management style may result in quite different outcomes. Many negotiators may have this kind of experience. Some people appear to be very approachable, attentive and receptive to demands, but in fact do not honor the promises. On the other hand, some individuals may appear very strong and tough at first, but they will conform to the commitment after an agreement is reached.

Kelman (1996) pointed out that conflict management is a process of social influence among parties. The outcomes of the conflict management are not only integrated into their own value system but highly dependent on the external social support system. The explorations eventually distinguish three processes of social influence--compliance, identification, and internalization (Kelman, 2004). At the level of compliance, conflict management involves accommodating differences apparently, but it is not likely to promote parties to commit to the outcome, since there is no change in the parties' underlying briefs and no improvement for the quality of the relationship. At the level of identification, conflict management involves an accommodation of parties' self-maintenance, which generates support to the agreement reached. At the level of internalization, the parties become better more capable in engaging joint problem solving, generating agreements that meet their needs and elicit their commitment, and are therefore conducive to relatively stable and effective conflict management (Kelman, 1996). In this regard, if there also exist some relationships between conflict management style and social influence system, it will be reasonable for such a corresponding relationship between conflict styles and the conflict management outcomes.

What is the actual relationship between the three social influence processes and conflict management style? An overview of the respective research literatures on conflict management style and social influence might help clarifying the nature of this disjunction.

2. Literature Review

Kelman (1996) developed interactive problem solving, as an informal approach for resolution of international and inter-communal conflicts, and applied it to the other conflicts between groups. A notable example is the Israeli-Palestinian conflict. In his opinion, people's behaviour not only depends on their own underlying briefs and value system, but also on the external influence, for example from their counterparts. He applied three processes of social influence—compliance, identification, and internalization to conflict management research.

In compliance process, an individual's concern focuses on the rule for conflict management (Kelman, 2006). In conflict management, each party is subject to being persuaded by becoming convinced that a particular result ought to be accepted because it is fair; because the law requires it; or because it is consistent with precedence, industry practice, or sound policy considerations (Fisher, 2001). This is the power of legitimacy (French and Raven, 2001). Compliance can be said to occur when an individual accepts influence in order to follow the "harmony and legitimacy" rule and avoid disagreement from the counterparts. Thus the satisfaction derived from compliance is due to the external effects, for example disagreement avoidance. Trubisky et al. (1991) and Ting-Toomey et al. (1991) pointed out that obliging style and avoiding style tend to emphasize the value for compliance and for maintaining relational harmony in conflict interactions. Obliging style has the effect of playing down differences and emphasizing commonalities to satisfy the concern of the counterpart (Rahim, 1992). Avoiding style is associated with withdrawal. It may take the form of postponing an issue until a better time or simply withdrawing from a threatening situation (Cai and Fink, 2002). There is an element of low concern on self with these two styles. This is because, in compliance process, disputants' concern focuses on disagreement avoidance and tries to enhance harmony. So if there is an chance to avoid disagreement by giving in to the other party's interest, they will attempt to accept the decisions the counterpart makes, deliver conceding statements and fail to express their own needs as what an obliging negotiator would do (Hocker and Wilmot, 1991; Rubin et al., 1994). If the benefit in yielding to the counterpart's needs is small and the conflict is unlikely to get a satisfactory solution, the party would withdraw from the threatening situation (Pruitt and Rubin, 1986). Like a "conflict absorber", avoiding style has low concern on self and others, known as suppression, which is associated with buck-passing, sidestepping, or "see no evil, hear no evil, and speak no evil" situations (Gross and Guerrero, 2000).

Hypothesis 1: Compliance nurtures avoiding and obliging styles.

Identification reflects an orientation to the role, not just as a set of behavioural requirements, but as an important part of their self-definition. Identification process nurtures people's self-maintenance in negotiation (Kelman, 2006). For example, Rahim (1986) described the styles of conflict management of an organizational member were affected by his or her referent role, ie. superior, subordinate or peer, since the hierarchical role between organizational members plays an important part in conflict management. He found that people were primarily obliging with superiors, but if failed, they would use dominating style to resolve the conflict. The tendency to strike back with a conflict move to deny or neutralize the challenge may be viewed as self-defense, a necessary self-maintenance mechanism (Vuchinich, 1987). Thus the satisfaction derived from identification is due to the self-maintenance. Ting-Toomey et al. (1991) found that self-maintenance was associated strongly with dominating conflict style. They assert their rights and defend a position. Sometimes they would aim to win at any cost, by using his or her position power to impose his or her will on the counterpart, including confrontational remarks, accusations, personal criticism, rejection, hostile imperatives or threats, antagonistic jokes or teasing, aggressive questions, presumptive remarks, and denial of responsibility at the expense of the other person (Pruitt and Rubin, 1986; Hocker and Wilmot, 1991; Gross and Guerrero, 2000; Cai and Fink, 2002).

Hypothesis 2: Identification motivates dominating style.

Internalization encourages people to maintain the congruence of actions and beliefs with their own value system. He accepts the idea because it is intrinsically rewarding (Kelman, 2006). Value congruence takes either the form of cognitive consistency, where the behaviour is perceived as conductive to the maximization of the person's own value, or the form of affective appropriateness, where the behaviour is perceived as continuous with the person's self-concept (Kelman, 2006). Fisher (2001) introduced two different kinds of commitments: affirmative and negative. Affirmative commitment was defined as an offer of what a person will agree to, or an offer of what, failing agreement, a person will do under certain conditions. Negative commitment was defined that a person was unwilling to make certain agreements, even though they would be better for him than no agreement, or that, failing agreement, a person will still engage in certain negative conduct, even though to do so would be worse for him than a simple absence of agreement. The affirmative commitment benefits from the relationship and is consistent with the person's own value system. Thus the satisfaction derived from internalization is due to the affirmative commitment. Thus at the level of internalization, the involved parties are more likely to exchange information openly, clear misunderstanding with each other, concern each other's interests and achieve mutually acceptable solution in conflict management (Rahim, 2001). It is found that people in integrating style and compromising style are more likely to develop trust, engage in constructive exchange of information, clearing up misunderstanding, making every effort to pursue a solution that will be mutually acceptable and seeking to understand one another's perspective (Pruitt and Carnevale, 1993; Gross and Guerrero 2000). They are more likely to uncover possibilities for trade-off or sharing whereby both parties give up something to seek a solution (Rubin et al., 1994; Cai and Fink, 2002).

Hypothesis 3: Internalization drives integrating and compromising styles.

The relationship between compliance, identification and internalization and conflict management styles are shown in *Table 1*.

Table 1: Relationship between compliance, identification, internalization and conflict management styles

	Social Influence Processes		
	Compliance	*Identification*	*Internalization*
Power Influence	*Rule*	*Role*	*Value Congruence*
Motivation/Concern	*Disagreement Avoidance*	*Self-maintenance*	*Affirmative Commitment*
Conflict Management Styles	*Obliging, Avoiding*	*Dominating*	*Integrating, Compromising*

3. Method

A questionnaire survey was used to collect data. Two types of data were to be collected from each response: conflict management styles and social influence processes. The respondents were asked to complete the questionnaire with reference to one of their recent two-party negotiation cases. For data on conflict management style, 35-item Rahim Organizational Conflict Inventory-II (ROCI-II) was used as the instrument (Rahim, 2001). Participants responded to each of the 35 items on a seven-point Likert-type scale from "Strongly Disagree" to "Strongly Agree". A high score represents a greater preference. As for the second type of data, it is based on the literature review of three social influence processes in conflict management (Kelman, 1996, 2006). Each factor consisted of 8 items, and the respondents were also asked to assess each of the eight items on a seven-point Likert scale.

A total of 250 questionnaires were sent to construction professionals holding senior positions in Hong Kong. 107 respondents completed questionnaires and returned to the research team. The response rate was 42.8% (107/250) of the respondents have more than ten-year experience in construction. As for employing organization, 14 responses were received from government, 7 from developers, 41 from consultant firms, 34 from main contractor firms and 11 from subcontractor firms. The respondents include 8 architects, 14 engineers, 52 surveyors, 24 project managers, 8 managers and one from other profession.

4. Results

Principle Component Factor Analysis (PCFA) is used to test the authenticity of the instruments to measure conflict management style and social influence process. Interpretation of variables can be accomplished by summarizing the data according to the developed constructs (Hair et al., 1998). Before performing PCFA, the suitability of the data was first assessed by using the Kaiser-Mayer-Olkin Measure (KMO) measure of sampling adequacy. The KMO value for the data of conflict management style and social influence processes are 0.683 and 0.718 respectively, which are above the threshold requirement of 0.5 (Cheung and Yeung, 1998; Cheung et al,. 2000). In addition, the low significance (0.00) of the Bartlett test of Sphericity for both the data of conflict management style and social influence processes suggests the adequacy of the data set to perform PCFA.

The most commonly used eignvalue-greater-than 1 principle was applied to select factors. Factors with eigen-value greater than 1 are considered as significant, factors with eigen-value less than one were discarded. Five conflict management styles, “Compromising”, “Dominating”, “Integrating”, “Obliging”, and “Avoiding” were identified from the Principal Component Factor Analysis. The final factor matrix for conflict management styles after Varimax rotation is given in Table 2. Three social influence processes “Internalization”, “Identification”, and “Compliance” were also identified by the Principal Component Factor Analysis. The final factor matrix after Varimax rotation is given in Table 3.

Table 2: Rotated factor matrix for conflict management styles

		Factor				
		1	*2*	*3*	*4*	*5*

Factor 1: Compromising						
Q21	*I negotiate with the counterpart so that a compromise can be reached.*	*.77*				
Q20	*I usually propose a middle ground for breaking deadlocks.*	*.68*				
Q19	*I try to play down our differences to reach a compromise.*	*.63*				*.39*
Q5	*I give some to get some.*	*.53*			*.41*	
Factor 2: Dominating						
Q18	*I argue my case with the other to show the merits of my position.*		*.74*			
Q8	*I usually hold on to my solution to a problem.*		*.69*			
Q24	*I use my expertise to make a decision in my favour.*	*-.45*	*.38*			
Q11	*I use my authority to make a decision in my favour.*		*.36*		*-.41*	
Factor 3: Integrating						
Q15	*I exchange accurate information with the counterpart to solve a problem together.*			*.74*		
Q29	*I collaborate with the counterpart to come up with decisions acceptable to us.*			*.66*		
Q6	*I try to work with the counterpart to find solutions to a problem with satisfy our expectations.*			*.59*		
Q1	*I try to investigate an issue with the counterpart to find a solution acceptable to us.*			*.59*		
Q4	*I try to integrate my ideas with those of the counterpart to come up with a decision jointly.*	*.58*		*.47*		
Factor 4: Obliging						
Q2	*I generally satisfy the needs of the counterpart.*				*.76*	
Q16	*I sometimes help the counterpart to make a decision in his favour.*				*.68*	
Q17	*I usually make concessions to the counterpart.*				*.61*	
Q30	*I try to satisfy the expectations of the counterpart.*				*.48*	
Factor 5: Avoiding						
Q34	*I generally avoid argument with the counterpart.*					*.73*
Q7	*I usually avoid open discussion of my differences with the counterpart.*					*.63*
Q22	*I try to stay away from disagreement with the counterpart.*					*.48*
Q32	*I try to keep my disagreement with the counterpart to myself in order to avoid hard feelings.*					*.41*
Q3	*I attempt to avoid being "put on the spot" and try to keep my conflict with the counterpart to myself.*					*.41*

Table 3: Rotated factor matrix for social influence processes

		Factor		
		1	*2*	*3*

Factor 1: Compliance				
Q22	*How much I contribute to cooperation is directly linked to how much I am rewarded.*	*.69*		
Q17	*Unless I get some reward for that concession, otherwise I see no reason to spend extra effort on it.*	*.58*		
Q19	*Sometimes I try to satisfy the expectation of counterpart in order to avoid being "punished".*	*.56*		
Q20	*I often go along with the counterpart to keep up my interest.*	*.53*		
Q18	*I feel worried and embarrassed when I argue with others.*	*.49*		
Q23	*Sometimes, my private views have to be yielded to what I express and behave outwardly.*	*.41*		
Q21	*I fear to open discussion on my disagreement, when the other party has strong power.*	*.37*		
Factor 2: Internalization				
Q5	*Only if the counterpart's statements are truthful and valid, the proposal could be worthy of consideration.*		*.79*	
Q7	*I will feel angry and disappointed if I feel my needs are not treated properly and fairly.*		*.79*	
Q4	*What I behave is consistent with what I believe.*		*.73*	
Q8	*I care about that very much whether the parties can exchange information with each other.*	*.38*	*.62*	
Q3	*I can't stand if there is no collaboration between parties.*	*.51*	*.52*	
Q6	*I would like to use "give and take" strategy to concern my interest and those of the counterpart's.*	*.46*	*.52*	
Factor 3: Identification				
Q13	*It is very important to show my authority and position.*			*.78*
Q10	*A conflict is not resolved unless the presenting relationship or interaction changed.*			*.76*
Q9	*I am proud to tell the counterpart my opinion and decision.*			*.75*
Q16	*I rarely care about the appropriateness in relational level.*			*.72*
Q11	*Self-face maintenance is quite important to me.*			*.69*
Q15	*I refuse if it is inconsistent with my value judgement.*			*.67*
Q14	*I argue to show the merits of my position.*			*.62*
Q12	*I feel heard and understood are the basic right.*			*.56*

The authenticity of the instruments for measuring conflict management and social influence processes were examined by comparing the items included for each factor with those indicated by the designer. The items retrieved for the five conflict management factors were identical to the original design of the instrument (Rahim, 2001). The interpretation of the factor classifications for the three social influence processes was fit well with the characteristics summarized in Table 1. As such, it is reasonable to use these instruments to measure conflict management styles of construction professionals and their social influence processes.

The relationship between conflict management style and social influence process were explored by the use of multiple regression analysis (MRA). Multiple Regression analysis is a statistical method to describe a functional relationship between a dependent variable and one or more independent variables. The general equation of regression model is shown as follows:

$$Y_i = \beta_{0i} + \beta_{1i} X_{1i} + \beta_{2i} X_{2i} + \beta_{3i} X_{3i} + \varepsilon_i$$

The dependent variable Y_i represents conflict management styles, where *i*=1,2,..5. The independent variables X_{1i}, X_{2i}, X_{3i} represent three social influence processes β_{0i} is unknown constant, and $\beta_{1i}, \beta_{2i}, \beta_{3i}$ are three coefficients for independent variables. ε_i is defined as random error.

The results of multiple regression analysis are shown in Table 4. R^2 value represented the combined effect of the entire variate in prediction and range from 0.697 to 0.946. As an illustration, the variable "integrating" and "compromising" are significantly related to the "internalization", with coefficient 0.579 and 0.570 respectively. Dominating style is recommended to the effect of identification influence, with the coefficient value 0.987 in Table 4. The variable "compliance" is strongly contributed to avoiding and obliging styles, with the coefficient value 0.750 and 0.555 respectively. The results strongly support the hypothesis that compliance nurtures avoiding and obliging styles, identification motivates dominating styles, and internalization drives integrating and compromising styles.

5. Discussion

Kelman (1996) pointed out that conflict management is a process of social influence among parties. At the level of compliance, the conflict management involves an accommodation of the parties' disagreement apparently, but it is not likely to promote parties to be committed to the outcome, since there is no change for parties' underlying briefs and no improvement for the quality of the relationship. Compliance nurtures avoiding and obliging conflict management styles. People of these two styles tend to be self-sacrificing and withdrawal, since these two styles tend to emphasize the value for compliance and for maintaining relational harmony in conflict interactions. Papa and Canary (1995), Gross and Guerrero (2000) found that the obliging style and avoiding style were ineffective in handling conflict. However Rahim (1986) pointed that obliging style may be appropriate when the issue is more important to the other party, and the avoiding style may be appropriate if the issue is minor or if a cooling-off period is needed to resolve the conflict. At the level of identification, the conflict management involves an accommodation of parties' self-maintenance, which generates support to the agreement reached. Identification motivates dominating style. That's why people of dominating style tend to be competitive because their conflict-handling behaviour is based on self-maintenance, and more unlikely to compromise. However Papa and

Table 4: Multiple regression analysis result

Dependent variables (conflict management style)	*Independent variables (social influence process)*	R^2	*Standardized regression coefficients*	*Unstandardized regression coefficients*
Integrating		*0.697*		*10.628*
	Internalization		*0.579*	*0.935*
	Identification		*-0.034*	*-0.036*
	Compliance		*-0.313*	*-0.652*
Avoiding		*0.852*		*-3.388*
	Internalization		*0.226*	*0.387*
	Identification		*0.029*	*0.033*
	Compliance		*0.750*	*1.599*
Dominating		*0.946*		*0.224*
	Internalization		*-0.087*	*-0.150*
	Identification		*0.987*	*1.122*
	Compliance		*-0.10*	*-0.021*
Obliging		*0.700*		*-0.749*
	Internalization		*0.320*	*0.333*
	Identification		*0.105*	*0.072*
	Compliance		*0.555*	*0.746*
Compromising		*0.747*		*9.552*
	Internalization		*0.570*	*0.770*
	Identification		*0.062*	*0.055*
	Compliance		*-0.378*	*-0.660*

Canary (1995) found that the dominating style might be somewhat effective in organizational contexts, if an individual uses power strategies and aggression to effectively accomplish a production-related goal, even though these strategies may be seen as inappropriate at a relational level. At the level of internalization, the parties become better able to engage in joint problem solving, generating agreements that meet their needs and elicit their commitment, and are therefore conducive to relatively stable and effective conflict management (Kelman, 1996). Internalization drives integrating and compromising styles. Therefore people of integrating style and compromising style are found to be provided each disputant with access to the other person's perceptions of incompatible goals, and enabled them to find a solution that integrates the goals and needs of both parties (Spitzberg et al., 1994; Gross and Guerrero, 2000). It was also found that integrating style was effective in achieving the functional negotiation outcomes, which is defined as problem solving, relationship maintained, and conflict reduction (Rahim, 1986), and the use of comprising style was proved as a practical approach in resolving a dispute (Cheung et al., 2006). This research integrates currently isolated lines of research on social influence theory on the one hand, and conflict management styles on the other hand. Compliance represents adherence to rule in conflict management. Identification reflects an orientation to the negotiator’s self-role. Internalization reflects an orientation to the value congruence, which encourages people to maintain the congruence of actions and beliefs with their own value system. Rules, roles, and values are the three central components in the process of conflict management. Negotiators must coordinate their actions with the counterpart respecting the rules, performing their roles and maximizing their values.

Different underlying social influences produce different patterns of styles of conflict management. It is found that the correlations between compromising and integrating, and the incompatibility occurs between avoiding and integrating style, and between dominating and obliging style, since compliance nurtures avoiding and obliging styles, identification motivates dominating style, and internalization drives integrating and compromising styles. Similar with the patterns of styles in this study, Weider-Hatfield (1988) concluded that "although the conflict literature has historically embraced the 'five-style' paradigm, recent evidence indicates that individuals might select among three, not five, distinct conflict styles" (p.364). Hocker and Wilmot (1991) summarized three conflict styles as (1) avoidance, (2) competitive (distributive) and (3) collaborative (integrative).

6. Conclusion

Construction is of long-duration, high value and dispute-prone. This study examines the relationship between three social influence processes and five styles of handling conflict. The results show that compliance nurtures avoiding and obliging styles, identification motivates dominating styles, and internalization drives integrating and compromising styles. This research integrates currently isolated lines of research on social influence theory on the one hand, and conflict management styles on the other hand. Compliance represents adherence to disagreement avoidance in conflict management. Identification reflects an orientation to the negotiator’s self-maintenance. Internalization reflects an orientation to the value congruence, which encourages people to maintain the congruence of actions and beliefs with their own value system. The findings also indicate that rules, roles, and values are the three central components in the process of conflict management.

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Considerations for a growth challenge: involving viable hands in construction

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Abstract

As Black and Minority Ethnics (BMEs) continue to be underrepresented in construction, discrimination, family pressures and the physical nature of construction jobs are but few of the perceived barriers to the recruitment and retention of qualified minority construction workers in the UK. Undoubtedly, construction continues to be characterised by a male-dominated, stereotyped image, with recruitment often arising through a number of informal channels notably personal referrals, thus affecting the proportional representation of minority groups and resulting in a considerable loss of human capital to the industry. However, perception and reality of the working environment have demonstrated a disparity and it is indeed necessary to correct this. Because researchers acknowledge that undertaking rigorous study on culture and ethnicity is complex due to its subjective nature, the development of appropriate methods, tools of analysis and mediums for reporting in this case would be central to this study. Therefore, this paper will attempt a comparative investigation of the issue from the perspectives of the stakeholders engaged in the field in two contrasting localities in terms of the diversity of their populations. It is believed that this study would help give a fairer picture of this situation in order to put forward suitable recommendations for the required action to be taken to address the situation.

Keywords: BME, construction, underrepresentation, recruitment, retention.

1. Introduction

As societies get more and more ethnically diverse resulting from demographic changes, organizations around the world cannot afford monolithic blocks of workforce and still compete on the global scene. As a result, an unparalleled impetus for a relatively large number of studies on the effects of diversity at work has been created and the construction industry in no exception. Undoubtedly, construction continues to be characterised by a male-dominated, stereotyped image, with recruitment often arising through a number of informal channels notably personal referrals. This serves as a major setback to the possible recruitment of minority groups resulting in a considerable loss of human capital. The need, therefore for the inclusion of minorities for the industry to be representative of the larger population cannot be stressed any further and this has been covered in several studies (Caplan et al, 2009; Ahmed et al, 2008; Caplan, A S and Gilham, J L 2005; Sodhi, D. 2004; Steele, A. and Sodhi, D. 2004; Egan J. 1998; Agapiou et al, 1995; Harrison, M. and Davis, J. 1995; Latham. M 1994;). However, studies into diversity at the workplace have generally yielded mixed results with some demonstrating that diversity can have negative effects by giving rise to communication difficulties thus affecting group cohesion and resulting in dysfunctional conflict (Jackson, Joshi, & Erhardt, 2003; Williams & O'Reilly, 1998). Yet, others (e.g., Caplan, et al 2009; Ahmed et al, 2008; Dinsbach, 2005; De Vries & Pettigrew, 1998; De Vries, 1992) indicate otherwise and hence see no reason why such problems should occur. This article therefore explores the issues relating to informal networks and the channels for BME entry into the construction industry.

2. BME background and socio-economic consideration

With a trend increase in immigration of more than 100,000 per year, the past four to five decades have seen Britain change from being a country of net emigration to one of net immigration (IPPR, 2010). Notwithstanding that improved economic performance in the UK relative to overseas has tended to increase immigration and rising UK inequality has had an even larger effect. Additionally, immigration policies at home and abroad have also helped to increase net immigration, particularly in the 1990s. According to the Labour Force Survey, some 4.5 million individuals living in Britain in the year 2000, 9% of the population, were born in another country (LFS, 2001). Many of these individuals of foreign origin work, and contribute to economic prosperity and well-being. And as supported by several studies, (e.g. Zimmermann, 2008; Dustmann et al, 2003; Shields and Wheatley Price, 2002; Dustmann and van Soest. 2001) differences in education, the demographic structure, culture, and skills of foreign-born individuals may have advantages in some labour market segments, but disadvantages in others and construction is classed in the latter category.

However, these disadvantages may diminish depending on the changes in the underlying factors and over time, immigrants may adjust in many respects to their UK-born peers, from the accumulation of skills, collection of information, and adoption of new habits. It is worthwhile to note that understanding how labour market performance of immigrants differs from UK-born, and from each other, how these differences relate to observed characteristics, and how they change over time is an important pre-requisite for migration policy. Also, it is significant to note that while adaptation and labour market performance of immigrant populations have been subject of intensive research in the US, Canada, Australia, and also in some European countries, according to Dustmann et al (2003), relatively little is known about the absolute and relative performance of the immigrant community living in Britain.

Notwithstanding, it is generally the case that when immigrants arrive in the destination country, their labour market productivity is likely to be different from that of the native born individuals; a situation attributable to different levels of education, socio-economic characteristics, and different demographic composition. But even if an immigrant is compared with a UK-born of the same education and age, they may differ in labour market outcomes, like wages and participation. One important reason for this is that the skills immigrants have acquired in their home countries are often not directly transferable to the host economy. Furthermore, immigrants may also lack certain general skills immediately after arrival in the host country especially fluency in communicating in the host's language as well as the observance of certain cultural practices. However, they may adjust over time to a level commensurate with the skills requirements of the labour market and in most cases acquire new skills. At this point, they may match or even do better in the level of local economic performance as well as assimilate into the hosts culture and hence the community.

2.1 Communication and occupational skills

Again, according to Dustmann et al, (2003), few studies in the UK analyse the determinants of immigrants' language fluency and the effect of language on economic outcomes. Studies by Shields and Wheatley Price (2002) based on the FNSEM found that higher education levels are associated with higher degrees of language proficiency, and that longer migration duration has a positive influence on language fluency. They further found out, by analysing the occupational success of non-white immigrants, that those who are fluent in English language have, on average, wages about 20 per cent higher than non-fluent individuals. This was further confirmed by Dustmann and Fabbri (2002) using results from both the FNSEM and the FWLS who further established a positive relationship between language, employment and earnings although this relationship did not necessarily indicate a causal effect of language on earnings (Dustmann and van Soest, 2001).

Consequently, the low level of participation among Black and Minority Ethnics (BMEs) in construction and their high unemployment levels generally have been blamed on their educational standards and efficiency in communication here in the UK and elsewhere in Europe. This said, however, the incidents of over-education among ethnic minorities (Battu and Sloane, 2002) cited in the UK with the accompanying high level of unemployment does not justify this assertion. Furthermore, ethnic minorities are well represented on construction related programmes in higher education here in the UK yet this is not reflected in their participation in the construction industry. It is without doubt that barriers to their participation exist in industries such as construction for in others like catering and cleaning they are known to be well represented even though they may lack the levels of skills required, they get the necessary on the job training and are able to progress with the limited communication skills they have.

2.2 The recession and future skills requirements

As has just been hinted in the preceding paragraphs, it is usually the case that in an efficient labour market where the supply of skills is aligned with labour market demand, the supply and demand matching processes are seen to be deficient where there are mismatches between demand and supply for skills. Therefore, it is easier to assume that skill shortages, skills gaps and general unemployment have been controlled in the current situation. This fact is consistent with the Construction Trade Survey (2009), where organisations across the construction industry all reported a considerable decrease in skill shortages to a record low. For instance, the recent Construction Products Association Trade Survey (Q3, 2009) reported that only 6% of building contractors had difficulties in obtaining the main site trades, a complete contrast to two years earlier when it was 78%.

Yet, looking at the recruitment activity, one in ten employers (10%) felt that there had been times when they lacked the number of skilled workers they required (ibid). Again, around half (52%) felt that they had been operating at around full capacity given the number of skilled staff they employed and still a third had not had enough work for their workforce (ibid). Also, it is worth noting that a more recent review of the Migration Advisory Committee's (2009) recommended shortage occupations listed civil engineers, mechanical engineers and welding trades while noting that although falling employment and vacancies and a high redundancy rate indicate that the labour market is in turmoil, it should not be assumed that all labour shortages disappear upon the acknowledgement that the removal of some construction-based occupations from the original list is in response to changing economic circumstances. Table 1 below shows the current unemployment rate for construction as it compares with all other industries in the UK.

Table 1. Unemployment rate in Construction Compared with All Industries by nation (UK: 2009).

Country	*Construction Industry*	*All Industries*
England	*8.3%*	*6.9%*
Wales	*10.3%*	*7.2%*
Scotland	*9.1%*	*5.8%*
Northern Ireland	*11.8%*	*5.6%*
UK	*8.6%*	*6.8%*

Source: Office for National Statistics, Labour Force Survey (2009)

As the data highlights in table 1 above, the construction industry has been significantly affected by the economic downturn, with the unemployment rate not only higher nationally, compared to the figure for all industries at 8.6% against 6.8% but it is even higher in each country as indicated. Here, it is significant to note that the unemployment rate across the Northern Irish construction industry is twice as high as the rate for all industries.

Therefore, it must be stressed that the impact of the recession across the construction industry has radically affected the mismatches between demand and supply. While on the one hand skills shortages and skills gaps have decreased dramatically, this has contributed to worsening unemployment. Although skills shortages are currently at an all time low, lessons need to be learnt from previous recessions. One of the biggest risks to the recovery of the construction industry, according to the ConstructionSkills (2009) is a shortage of skills as people made redundant seek new careers outside the industry and new entrants unable to get jobs, look elsewhere.

3. Critical findings from existing literature

After the foregoing review of literature on the subject, key findings emerge on the basis of which deliberations will guide attempts at possible means of resolving the problem on hand. Primarily, the problem seems widespread in all major and bustling economies where labour is attracted as a result of the attractiveness of the associated reward which is usually nowhere comparable to the immigrants' home country. Therefore, the tendency to relocate to such economies with all its attractions is very high which results in the movements of peoples. It is a fact that others may relocate as a result of reasons and circumstances beyond their control but then in the labour market distinction is not made and all suffer same treatment. As conditions are usually different in the countries of origin, in respect of say education and training, culture and work experience there is always a level of bridging required to adjust. Consequently, such differences in the labour markets, for instance in the European Union countries are mainly blamed on the low educational level of minorities as well as ineffective language and communicative skill and the low educational attainment yet BMEs in the UK have been noted to be over-educated and still may not usually benefit from this. In any case, giving the opportunities available here some immigrants take advantage and perform better; a case in sight cited earlier in this paper where in France a more than proportional number of ethnic minorities continue to High School compared with their native majority.

Therefore, as language requirements for higher level jobs and non-transferable skills may not explain this finding, discrimination is certainly said to be the latent contributor as it has also been noted that economists often find inexplicable differences in the labour market outcomes of ethnic minorities and the majority population to which they attribute the same reason. Although employment among ethnic minorities has increased over the past few years, the average unemployment levels among ethnic groups still hovers around 4 times higher and the net participation rates are lower than among the Dutch native population. Additionally, long-term unemployment is relatively high among non-western minority members and many of the employed occupy lower job levels. By and large, this can be explained by factors at the level of the different ethnic groups themselves, as already indicated earlier involving their lower levels of education, their often one-sided work experience and limited social networks and it is worth reiterating at this point that networking has been identified as a strong job hunting tool in entering unto the career ladder and progressing. This said, however, institutional factors basically underlying conscious or unconscious discrimination by employers also play a major role.

To a great extent, numerous legal provisions to protect and treat ethnic minorities fairly are in place in almost every country and more so in the UK, the Race Relations Act (1976) played a leading role to outlaw discrimination against anyone on the grounds of race, colour, ethnic or national orientation. Moreover, the establishment of the Commission for Racial Equality, and later as a merger into the new Equality and Human Rights Commission (EHRC) was seen as a pointer in the right direction and a finite remedy to deal a deadly blow to the situation yet their efficacy has been questioned as to whether these go far enough. For example, it is one thing suffering discrimination and abuse and another reporting and even seeking redress conscious of the inherent consequence associated with this. Moreover, the numerous firms as well as the fragmented nature of the construction industry may not easily yield to such monitoring.

If generally, white Irish men are more likely to work in the construction industry a figure put at 21 per cent compared with 12 per cent overall and compared with 2.3% BME people between 1999 and 2000 either directly employed or self employed within the UK construction industry with the remaining being white then much needs to be done. Furthermore, if employment within the sector is skewed towards the South East with well over a third (37%) of the workforce based across Greater London and the South East where the greater majority of BME people are concentrated then it is very worrying that participation in the industry it this low. Also, unwillingness or otherwise on BMEs to relocate to the North East which has quite a high demand for new entrants due to the significant level of net outflow of the workforce in the region is a worrying factor requiring attention for mitigation.

4. Methodology

In conducting the study, a large amount of literature is synthesised following which an empirical study follows as described below. The analysis is based on the survey of both employer and employee components, covering a broad range of topics from both the demand and supply side of the labour market based in the specific domain of construction in the UK. The respondents are sampled by physical location, based on the two identified regions of the NW and SE base on age (18 years or over) and employee/employer status. The survey design focuses on construction organizations of varying sizes in both regions selected while considering anonymity and confidentiality concerns as ethics demand irrespective of their composition. The basis of this study is to assess the underlying causes of BME underrepresentation in construction for which reason the data collected is solely aimed at soliciting information in that regard. It is without doubt that the formal channels of entry into construction employment is universal however, it has been noted as not being the major source of labour supply into the industry. It is for this reason that the informal channels, which favour sections of societies depending on ownership and location, are critical to this study.

This is an opportunity to present some preliminary findings from this study through quantitative data collected using questionnaires survey mainly for complementary purposes. This was base on relying on the views of employees as the ones best placed to tell the story since they are the direct sufferers of the selection process for any vacancy that gets filled. One would have thought that it would be appropriated to solely collect evidence from the BME employees for a true picture but then as it immerged in the interview process, non-BME employers and managers were better placed in giving the true picture of the situation as it really is because whatever they said, because they did not belong to the group being studied could be devoid of any bias. Furthermore, because most of them had more control and were higher up in line of authority, they had confidence in what they had to say and feared no consequences. These were however the observations of the researcher from studying the features of the respondents.

The wide variety of construction professions and hence the diverse nature of its employees made it mainly feasible for a questionnaires survey in order to save time and other resources and to cover a wider cross-section of this sample set.

Table 2: Respondents mode of entry to industry based on relations in industry by region

Region			*Relation in industry*			*Total*
			No answer	*Yes*	*No*	
NW	*Mode of Entry into construction*		*1*	*-*	*2*	*3*
		Job Centreplus		*2*	*-*	*2*
		Newspaper advert		*1*	*1*	*2*
		College Career advisor		*-*	*5*	*5*
		Direct application		*1*	*4*	*5*
		Recommended by a friend		*5*	*3*	*8*
		Recommended by a relative		*2*	*-*	*2*
		Other		*-*	*1*	*1*
	Total		*1*	*11*	*16*	*28*
SE	*Mode of Entry into construction*	*College Career advisor*		*1*	*2*	*3*
		Direct application			*1*	*1*
		Recommended by a friend		*13*	*6*	*19*
		Recommended by a relative		*21*	*3*	*24*
	Total			*35*	*12*	*47*

NB: *NW – the North West Region of England*

SE – London and the South East Region of England

The questionnaires were targeted solely at employees in construction in the two locations of London and the South East region and the North West region of England.

It must be admitted here that the data collection process was bridled with difficulties in the response rate. This was to account for the wide differences in the composition of ethnic minorities in the population of the two locations with the former being very high and diverse while the later is comparative sparse in this respect. For this reason, snowball sampling techniques were adopted to increase the response rate. Out of 200 questionnaires distributed equally in both regions, 75 were returned duly completed on which the analyses presented in this paper were based. Using the computer software SPSS for analysing the data, the pertinent aspect relevant for presentation in this paper yielded table 2 above.

This resulted from a cross tabulation of the respondents regions and the correlation of the factors '*mode of entry into the construction industry*' and '*relation in industry*'.

5. Preliminary findings from empirical data

Reading from table 2, it becomes clear that the response rate was higher in the London and the South East region where a total of 47 respondents filled in and returned the questionnaires while the North

West region yielded 28 responses, that is, just over half of the former. This could have resulted from a comparatively higher incidence of BME presence in the region, as it emerged, who participated in the study. The correlation between the two main variables – *mode of entry in construction* and *relation in industry*, in both regions, as indicated in table 2, shows that wider networks in the industry is a strong determinant of the opportunities open to any potential employee. Although this platform does not permit a complete coverage of the findings, it is however worth noting that the majority of the employees who gain their jobs through referrals from relatives and friends had the right to the jobs anyway as these businesses were owned and/or managed by the people who had engaged them. This, in effect, confirms the references made to the high prevalence self employment in literature by ethnic minorities as an attempt to create their own employment and engage their relations forming their own networks which hints the beginning of the process of reverse discrimination but then this is a subject outside the scope of this paper.

In the SE, relatives were a very strong factor in looking for work in construction while in both regions friends happen to be formidable force if one is to gain employment in the industry. Furthermore, institutional career advisors also have been shown to play a significant role although slightly more in the NW.

6. Conclusion

Therefore, it is worthy of note that the formal channels available for job applications for entry into construction don't seem to appeal to ethnic minorities. The main established routes for entry found to be informal networks of friends and relatives do not, on the whole, appeal to BME members as their participation has been noted to be generally limited. However, in London and the South East Region for the study, it was noted that these were very significant modes of entry. To this effect, the high multiethnic ratio of this region suggests that certain sections of BMEs have some established networks they can tap into for entry into the industry. Again, in the SE it was found that level of education and language which have been said to be strong inhibitions for the BME in looking for work in construction in the UK and elsewhere in Europe appeared somewhat invalid as there were in some companies, members of staff who hardly understood any English at all. This reinforces the same reason of established networks as employees in this category can only function in their roles if they can understand instructions which obviously must originate from someone they can communicate with. Consequently, the low level of participation among Black and Minority Ethnics in construction and their high unemployment levels have to find their reasons elsewhere other than what has been assigned.

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Relational Pluralism in Project Settings: Towards a Research Agenda

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Abstract

Construction projects are characteristically complex undertakings whose successful realisation requires the engagement of a myriad of individuals, teams and organisations. Projects therefore provide a platform for the emergence of multiplex (i.e. entities having more than one type of relationship), heterogeneous (i.e. entities connected to others from different backgrounds) and overlapping (i.e. entities belonging to clusters or spanning boundaries) relationships. This notion of the existence of relational pluralism in projects has implications for project constituents and project delivery. For individuals, it is how to grapple with multiple and conflicting identities in achieving outcomes. For teams, it is how to grapple with multiple types of inter-team relations and still maintain harmony to achieve goals, and for organisations, it is how to deal with the multiplicity of relationships among individuals and teams and still achieve goal congruence. This paper draws on social identity theory, social network theory and social capital, and their complementarity to explicitly examine the presence of multiplex, heterogeneous and overlapping relationships in projects and explain how relational pluralism can be exploited to facilitate effective project delivery. We further highlight the research avenues relational pluralism presents in project settings and examine the methodological implications of such research agendas.

Keywords: Identity, project settings, Relational pluralism, social capital, social identity theory, social network theory

1. Introduction

The social networking zeitgeist appears to be here to stay and organizations are beginning to grapple with how the networks developed through social networking can help employees and the organization as well. Social networking has particularly highlighted the improbable task of trying to segregate relationships in different spheres of life in contemporary society and work settings (Ingram & Zou, 2008). An increasingly complex and uncertain business environment has also made understanding how individuals manage the delicate balance of relationships within groups, across organizational units and across hierarchical levels even more important (Oh, Chung and Labianca, 2004).

The workdays of most individuals involve interactions with colleagues, often necessitated by hierarchy or workflow requirements (Shah, 2010). Other interactions are however voluntary, generally self-generated, self-organized, and self-managed (Morton, Brookes, Smart, Backhouse, & Burns, 2004). These interactions result in individuals, teams and organizations forming complex and intertwining webs of relationships, a phenomenon captured under the rubric of relational pluralism, the notion that a focal entity (whether a person, a team, or an organization) can derive some meaning and possibility of action from relations with other entities (Gulati, Kilduff, Li, Shipilov and Tsai, 2011).

The importance of interpersonal relations, team spirit and collaboration is a recurring theme in construction management (Nicolini, 2002). The institutional arrangements through which projects are delivered therefore make relational pluralism inevitable. Construction projects are characteristically complex undertakings whose successful realization require the engagement of a myriad of specialist individuals, teams and fragmented as well as differentiated organizations (Styhre *et al.*, 2004). Projects therefore provide a platform for the emergence of relational pluralism, manifested in the form of multiplex relationships (i.e. entities having more than one type of relationship), heterogeneous relationships (i.e. entities connected to others from different backgrounds) and overlapping relationships (i.e. entities belonging to clusters or spanning boundaries) (Gulati et al, 2011). This paper explores the notion of relational pluralism in projects and its manifestations as well as implications for project constituents and project delivery. We draw on social identity theory, social network theory and social capital, and their complementarity as theoretical foundations to support the notion of relational pluralism. A research agenda highlighting the research avenues relational pluralism presents in project settings is offered as well as the methodological implications of such research agendas.

2. Theoretical Foundations of Relational Pluralism

The idea of relational pluralism has a long history, dating to the time of the ancient Greeks and idea that individuals have multiple selves from which unique identities are formed (Gulati et al, 2011, Obodaru, 2012). Since then, the question of whether to place emphasis on the plurality of selves or unitary nature of identity still remains. The psychologist William James (1890: 294) asserts that a person has as many social selves as they were other individuals who recognized the person and carried an image of the person in their mind. In support, the sociologist Georg Simmel (1955: 150), argued that individuals become unique to the extent that they affiliate with many different non-overlapping groups. Relational pluralism is defined as the extent to which a focal entity (whether a person, a team, or an organization) derives its meaning and possibility of action from relations with other entities (Gulati et al, 2011). Gulati et al (2011) characterise relational pluralism along three dimensions of relationships; multiplex, heterogeneous and overlapping. In the sections that follow, we explain the foundation multiplex relations as rooted in social exchange theory, heterogeneous relationships as rooted in social identity theory and overlapping relationships as rooted in social capital. The complementarity of these theoretical foundations provides a profound grounding for the notion of relational pluralism.

3. Multiplex Relationships

Multiplexity is defined as the extent to which actors are connected by more than one type of relationships (Gulati et al, 2011, Tichy, Tushman, & Fombrun, 1979). Multiplex relationships are rooted in social network theory and the notion that individuals, teams and organizations are invariably embedded in social systems and therefore form complex web of relationships among actors (Wasserman & Faust, 1994). Such actors therefore share “multiple bases for interaction” such as roles, actions, affiliations and exchanges (Verbrugge, 1979, Marsden & Campbell, 1984, Wasserman & Faust, 1994). Multiplex relationships are pervasive and can be exemplified by co-workers who are also friends, siblings running a business together, business associates entertaining clients on the golf course, and spouses belonging to different political parties (Kuwabara, Luo and Sheldon, 2010). Relationships can be multiplex on the basis of instrumental ties or affective ties if they introduce different norms of interaction (e.g. a parent and a child who simultaneously think of themselves as close friends) (Kuwabara, Luo and Sheldon, 2010). Multiplex relationships are distinct from repeated interactions, although multiplex relations necessarily involve repeated interactions but to be multiplex actors must interact on the basis of the same/different roles, actions and affiliations that overlap in time and space (Kuwabara, Luo and Sheldon, 2010). Organizational network scholars have previously overlooked multiplex relationships, due to an assumption that the instrumental component of relationships has independent consequences, while any social component plays an ancillary role (Shah, 2010). Shah (2010) contends and finds support that in multiplex ties, the instrumental and social components interdependently, rather than independently, affect performance.

3.1 Heterogeneous Relationships

Heterogeneity is the extent to which actors form connections with others from quite different backgrounds (e.g., different ethnicities, professions or industries) Gulati et al (2011). The notion of heterogeneity is rooted in identity theory. Indeed, social identity theorists have long emphasized the importance of relational aspects of self-identity (Brown and Phua, 2011) with some opining that identity construction involves the realization and ascription of ‘relationships of similarity and difference’ (Jenkins, 2004, p. 5). Social identity theory explains the self-categorisations that individuals use to enact their sense of belonging (i.e. identification) with particular human aggregates or groups that reinforces their self-conceptions (Ashforth and Mael, 1989; Tajfel and Turner, 1985). It therefore helps individuals answer the question, Who am I?, by delineating the social groups in which they are members (Pratt and Rafaeli, 1997, Alvesson, Ashcraft and Thomas, 2008). While the need to identify may seem to suggest the formation of homogeneous rather than heterogeneous relationships, many scholars have stressed the dynamic character of the social world, pointing out that identity is temporary, context-sensitive and involve evolving set of constructions, rather than a fixed and abiding essence (Ashforth, 1998; Gioia et al., 2000, Gioia et al, 2010, Alvesson, Ashcraft and Thomas, 2008). Identity from this perspective can involve a negotiated process through which relationships are forged between actors who may otherwise have distinct identities (Gluch, 2009, and; Paton et al., 2010). Smith-Lovin (2007) also suggests that the high degree of differentiation and specialization in modern societies is “thinning” relationships toward unidimensional, simplex relations, at least in very close and personal circles. As identities are negotiated and formed, joint efforts to resolve relational conflicts arising from heterogeneity can build people’s sense of efficacy in their abilities to work together and build relationships that have positive consequences (De Dreu & Vliert, 1997; also Lawler, 2001). Some research however suggests that heterogeneity can have negative consequences. Smith and Postmes (2011) found example that group interactions can lead to increased out-group discrimination due to identity stereotypes and categorisations. Heterogeneity should therefore afford combining relationships from different spheres of life while taking measures to counter any negative consequences.

3.2 Overlapping Relationships

Overlap is the extent to which the focal actor's relationships are clustered in one group or span across different groups (Gulati et al, 2011). A typical manifestation of overlapping relationships in a network structure context is the notion of closure (i.e. closed networks) (Coleman, 1988). Closed networks are characterized by ties that alter who are connected to each other, creating densely connected cliques in which for example “a friend of a friend is also a friend”. Closed networks might facilitate the formation of multiple relations to the extent that actors in closed triads interact more often and share broader bases of exchange with one another (Kuwabara, Luo and Sheldon, 2010). This structural network of relationships is at the heart of Coleman’s (1990) analysis of social capital and Granovetter’s (1985, 1992) discussion of “structural embeddedness”. This network structure fosters trust, as a given relationship “surrounded’’ by other relationships reinforces their commonalities and provides structural checks against deception and malfeasance (Chua, Ingram, et al., in press). The notion of overlapping relationships is rooted in social capital, which encompasses the resources embedded in the structure of social relations among individuals (Burt, 1992; Coleman, 1988; Nahapiet and Goshal, 1998). The three dimensions of social capital (i.e. structural, relational and cognitive dimensions) are particularly consistent with the notion of overlapping relationships and form the basis for developing some capital from relationships to accomplish tasks (Koh, Rowlinson and Tuuli, under review, Nahapiet and Goshal, 1998).

4. Manifestation and Implications of Relational Pluralism in Projects

Relationships are central to the successful delivery of projects. Indeed, relational issues are often the cause of breakdown in teams rather than the technical complexity of projects (Fong and Lung 2007).

Relationships therefore have important consequences for different constituents in project settings. For individuals, it is how to grapple with multiple and conflicting identities in achieving outcomes. For teams, it is how to grapple with multiple types of inter-team relations and still maintain harmony to achieve goals, and for organizations, it is how to deal with the multiplicity of relationships among individuals and teams and still achieve goal congruence. In the sections that follow, we explore the manifestation of relational pluralism along the three dimensions of multiplexity, heterogeneity and overlap.

4.1 Multiplex Relationships in Projects

Because of the division of labour in many work contexts, we necessarily have to enter into relations with other entities to obtain information, resources and support to accomplish tasks (Durkheim, 1984) and this interdependence is particularly more apparent in construction project settings. In projects, multiplex relationships are particularly ubiquitous, often requiring constant negotiation of the challenges they bring. The longer work hours in projects also mean that people are more likely to form social relations within the confines of their work (Verbrugge, 1979). Yet, in projects in some contexts, multiplex relationships are actually actively avoided, ostensibly to prevent the trials and tribulations of mixing business and pleasure and the conflicts of interest that come with them. In Hong Kong for example, the consultant and client project teams need to abide by stringent ethical regulations at the project-level, particularly on public projects. The fear of being investigated or prosecuted by the Independent Commission Against Corruption (ICAC) is particularly strong, following the incidents of sub-standard piling of 2000 in the Hong Kong construction industry. This is a deterrent to the development of close or multiplex relationships at the project-level unless these are purely based on professional issues or clustered within the client or consultant organizations. Yet, people care profoundly about multiplex relations, both about their own and others (Kuwabara, Luo and Sheldon, 2010).

Partnership (strategic and project partnering) represents one example where multiplex relationships are actively encouraged in projects across the supply chain. In particular, organizations sponsor social activities outside of work to promote team-building (Kuwabara, Luo and Sheldon, 2010). Beckman and Haunschild (2002) find evidence that strategic alliances and CEO association memberships reinforce interlocking ties, which enhance learning and transfer of complex acquisition knowledge. They conclude that the more multiplex relations a firm possess with its network partners, the lower the price that the firm paid for its acquisitions.

Multiplex relationships however have other implications in project context that are worth mentioning. For work-life balance issues the network of relationships that emerge from multiplexity further blurs work and social life spheres. There is also the potential for tensions and role conflict to emerge as a result of the web of multiplex relations of focal entities. Thoits (1983, 1986) examined how maintaining multiple roles affects psychological well-being, demonstrating however that multiple identities and roles, such as spouse and employee, provide various benefits, including resource aggregation, justification for failing to meet certain role expectations, and buffering against role failure, which can help mitigate psychological stress.

4.2 Heterogeneous Relationships in Projects

Construction projects are delivered through the assembly of specialized and differentiated teams. The formation of heterogeneous relationships between individuals, teams and organizations of different professional identities and disciplines is therefore inevitable. Formal heterogeneous relations are required because projects are characterized by both operational interdependence and organizational independence (Dubois and Gadde, 2002, Gluch, 2009). As Nicolini (2002, p. 167) points out, “interpersonal relations, team spirit and collaboration is a recurring theme in construction management”. Heterogeneous relationships in projects provide a platform for identities to be negotiated, threatened, supported and contested through ongoing interactions among interconnected and interacting project participants (Brown and Phua, 2011).

Heterogeneous relationships therefore have implications in projects. At the dyadic level, the extent to which people conform to each other's identities affects cooperation and performance (Phua, 2004, Milton & Westphal, 2005). The tension that arises from incompatible identity-related norms can strain relationships by causing role conflict, miscommunication, or misalignment of mutual interests and expectations (Ingram & Zou, 2008). These can manifest in project joint ventures, for example, which are increasingly needed to meet the technical and operational complexity of projects.

4.3 Overlapping Relationships in Projects

Overlapping relationships manifests in various ways in projects. Examining social capital in projects, Koh, Rowlinson and Tuuli (under revision) found that the structural dimension, consistent with overlapping, manifests itself through facilitating information and communication, transfer of influence and authority, provides a forum through which project members can evaluate the trustworthiness, reputations, quality, and affiliation of other members. In support they also found in tandem with previous research that the relational dimension provides a normative structure that helps the generation of a common set of convention, climate, rules and routines (Granovetter 1992, Koh, Rowlinson and Tuuli, under revision). Also as discussed above, resistance to the formation of multiplex relationships across organizational boundaries as a result of corruption concerns can lead to the clustering of plural relationships within organizations.

5. Towards a Research Agenda and Methodological Challenges

The relatively unexplored nature of relational pluralism in projects presents fertile avenues for future research in construction management. Some of the preliminary research in this field in project settings includes those exploring social capital in projects (cf. Koh, Rowlinson, Tuuli, under review, Koh and Rowlinson, in press, Bresnen et al 2003), relationship marketing (c.f. Bengtson, Havila and Aberg, 2001: Dubois and Gadde, 2002), relationship management (c.f. Kadefor, 2004, Holmen, van der Veen and Doree, 2002, Cheung et al, 2005) and relational contracting (c.f. Anvuur, Kumaraswamy and Mahesh, 2011, Pryke and Smyth, 2006). Thus, although relational pluralism is pervasive in projects, we know surprisingly little about when, under what circumstances, and exactly how the ties that emerge from multiplex, heterogeneous and overlapping relations strengthen or weaken relationship ties (Kuwabara, Luo and Sheldon, 2010). The dynamics and consequences of relational pluralism also remain understudied. Shah (2010) from an organization studies perspective for example, shows that there are individual performance consequences of multiplex relations. From the perspective of projects, while the above provide fertile avenues for research, a more productive agenda may be to start mapping the manifestations and dimensionality of relational pluralism in project settings. This will provide contextual grounding to the notion of relational pluralisms and afford the examination of the antecedents and consequences of plural relationships.

Methodologically, researching relationships and human interactions is challenging especially within the construction management domain which lacks strong methodological tradition or proven methodologies or methods. While this presents opportunities for experimenting with methods drawn from other disciplines such as the social sciences, the ability of researchers to appropriately employ such methods represents a challenge on its own. An approach, which may be suited to exploring relational pluralism, is a mixed methodological approach (c.f. Creswell, 2003) where quantitative and qualitative methods will be blended to reveal different and complementary perspectives (Steckler et al, 1992) of a complex concept such as relational pluralism. The combination of quantitative and qualitative methods in social research is supported by many researchers who argue that theory building requires 'hard' data for uncovering relationships and 'soft' data for explaining them (c.f. Dainty, 2008, Loosemore *et al.,* 1996). Making the case for social researchers in construction management to embrace *methodological pluralism,* Dainty (2008) argued that such an approach has the potential of providing better understanding of the complex network of relationships which shape industry practice. Since different paradigms focus attention on different aspects of a situation, methodological pluralism is warranted to capture the full richness of real world problems, such as relational pluralism, which are often highly complex and multidimensional (Mingers and Brocklesby, 1997). Methodological pluralism, however, is not without problems. Philosophically, there is the issue of paradigm incommensurability, the view that the underlying assumptions in different paradigms are irreconcilable; theoretically, it is a challenge to effectively fit different methodologies together; and practically, researchers are unlikely to have the wide range of knowledge, skills and flexibility required to effectively implement a multimethod study (Mingers and Brocklesby, 1997). To overcome the philosophical dilemma of paradigm incommensurability, an ontology of *critical realism* may be invoked which subsumes the objective-subjective dichotomy; a view supported by the work of Bhaskar (Bhaskar, 1989, Bhaskar, 1994) and Giddens (1984) on structuration theory, both of whom reject the notion of choosing between the competing realities offered by realist or normalist thinking. This ontological position allows researchers to combine methods and techniques from originally competing paradigms without the need to constantly adjust philosophical positions depending upon whichever method is being used at any given time (Mingers and Brocklesby, 1997). To address the theoretical difficulties of linking different methodologies or parts of methodologies in a systematic manner a sequential framework may be adopted, in which qualitative approaches are followed by quantitative approaches for example. Lastly, the practical problems of undertaking a multimethodological study can be overcome by drawing together a team of researchers with prior training and experience of employing a wide range of qualitative and quantitative methods in previous research projects.

Another promising methodological approach for examining relational pluralism is multilevel analysis. Although relational pluralism manifests across individuals, teams, and organizations, researchers are yet to explore relational pluralism from a multilevel perspective. How relational pluralism at one level affects the emergence of status and power at other levels for example, presents fertile avenues for future research. Such multilevel studies can employ diary data together with social network analysis through case study approaches (c.f. Yin, 2003) in order to capture the emergence of multiplex, heterogeneous and overlapping relations in projects.

Other research avenues worthy of consideration include the moderation and/or mediation role of relational pluralism in the relationship between constructs of interest in project context. For example, while organisational, team and individual capabilities may have a direct link to project performance and outcomes, is it possible that indirect benefits of capabilities for project performance could exist through the relationship networks that individuals, teams and organisations develop (i.e. relational pluralism)? Preliminary studies by Koh and Rowlinson (in press) are suggestive of the possibility of such mediating/moderating effects.

6. Conclusion

Relational pluralism manifests in projects in the form of multiplex, heterogeneous and overlapping relations. Preliminary research in projects show that the relational approach, which promotes intensive social and professional interactions, has some performance implications for individuals, teams and organizations involved in projects (cf. Koh, Rowlinson, Tuuli, under review, Bresnen et al 2003, Carey et al. 2011). This paper draws on social identity theory, social network theory and social capital, and their complementarity to examine the emergent multiplex, heterogeneous and overlapping relationships in projects and has shown that relational pluralism can be exploited to facilitate project delivery. The largely unexplored nature of relational pluralism in projects presents fertile avenues for researchers. Pursuing such research avenues could help us better understand how relational pluralism shapes the dynamics of relational interactions in projects and the impact on project outcomes.

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Giving an energy target sense: focus on an expert and discursive competences

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Abstract

EU has launched a new directive on energy efficiency for buildings. This directive forces property owners/builders to reduce their energy use which in turn requires large investments. As a consequence there is a need for these organisations to change their investment strategies and practices. This paper aims to contribute to our understanding of how an EU directive on energy use in buildings diffuses into, and is managed by, a public construction client organisation. Drawing on a framework of Rouleau and Balogun, we have examined how discursive competences were deployed by an energy expert as means to influence the organisational sensemaking of the target initially. The paper is based on an explorative case study, namely in-depth interviews with seven respondents, a focus group meeting and extensive field notes. Using a narrative approach, we account for talk, action and interaction between mainly the energy expert, the management team and officials. Thus, we unfold how the sensemaking of the target progressed over time.

Keywords: discursive competences, sensemaking, expert role, energy target, public construction client

1. Introduction

A new EU directive states that the energy use in buildings should be reduced significantly during the coming years (European Commission, 2010). How to meet this directive is thus an important topic discussed in many public authorities on national, regional and local levels as well as in construction client organisations all over Europe. The public sector is expected to take the role as fore runner in this development (European Commission, 2010) which has resulted in ambitiously set energy targets in public buildings in for example Sweden (The Swedish Ministry of Enterprise, 2011, Dalenbäck and Mjörnell, 2011). Accordingly many construction client organisations are currently facing a need to find appropriate ways to reduce energy use in their buildings. To meet these targets will, besides technology development, require a change of strategies, practices and behaviour in all public organisations involved in construction and refurbishment of buildings. However, organisations consist of individuals that make sense of their situation out of their context and pre-understanding (cf. Clegg et al., 2011). This implies that management has to find ways so that the directive as well as set targets can be made sense of by the concerned individuals.

This paper is based on a case study in a public construction client organisation in Sweden. We have studied how a target on reduced energy use in buildings was translated into the organisational context and managed. Using sensemaking (e.g. Weick et al., 2005) as theoretical lens, we can understand what happened in the organisation when confronted with an ambitious energy target. Sensemaking has previously been used by scholars to explain how managers initiate, address and distribute meaning about organisational changes and crises (cf. Maitlis and Sonenshein, 2010). It has also been shown that in order to implement changes, managers need to influence how others make sense by dispersing their own understanding of the change and/or the crisis (e.g. Gioia and Chittipeddi, 1991, Maitlis and Lawrence, 2007). Here the role of the middle managers has been of particular interest since although they lack the authority that top managers have, they need to influence upwards, laterally and downwards in the organisations (Rouleau and Balogun, 2011). As shown by Rouleau and Balogun, middle managers do not only use conversations to influence people in their surrounding, but a range of different discursive competences to set the scene for where these conversations should be done and how. Drawing on their work this paper explores how discursive competences are used to influence actions and make sense of the energy target within a public construction client organisation. Specific focus is on the discursive competence of an energy expert, working at the R&D department, in interplay with for example the management team and other officials. The paper presents an account of what happened in the organisation from the point where the target was initially discussed in early 2010 up to the point when the target was anchored in the organisation in autumn 2010. This case provides an opportunity to study how meaning was made out of the target and how it was contextualized within the organisation. Since public construction client organisations all over EU face the same directive as our case organisation the study provides valuable insights for a broad spectrum of actors within the construction sector, such as policy makers, managers, energy experts and academics.

2. Making sense in organisations

With sensemaking we mean the cognitive process of how we construct meaning of what is going on around us. The concept is often accredited Karl Weick who has developed the theory of sensemaking (for later examples see e.g. Weick, 1995, Weick, 1988, Weick et al., 2005). Some of the inherent characteristics of sensemaking, as defined by Weick (1995), embrace for example that sensemaking is a continuously ongoing, social process where people search for plausible, though not necessary the most accurate, understanding. In this sense, sensemaking is conducted when the actors scan their environment and decide on what new information is relevant to interpret and take action on. Hence, it is the process where people generate what they then interpret (Weick, 1995: 13) and not the interpretation in itself. Although closely linked and often misused as a synonym (Weick, 1995), interpretation should not be used interchangeably with sensemaking. For the purpose of this paper, sensemaking is defined as “a social process of meaning construction and reconstruction through which managers understand, interpret, and create sense for themselves and others of their changing organisational context and surroundings (Rouleau and Balogun, 2011).

Sensemaking has received significant attention in organisational management and change research during the last two decades (e.g. Maitlis and Sonenshein, 2010 for an overview), but is still under-represented in construction management literature (cf. Leiringer et al., 2009). The approach has been applied as a mean to understand and explain how managers at different organisational levels initiate, get acceptance for and implement organisational change (e.g. Gioia and Chittipeddi, 1991, Rouleau, 2005, Rouleau and Balogun, 2011, Stensaker et al., 2008). In this paper, we pay attention to how actors develop mutual understanding as well as to how they influence people in their surroundings to adopt their view. The latter is referred to as ’sensegiving’ (Gioia and Chittipeddi, 1991, Maitlis and Lawrence, 2007). Sensegiving is described as “the process of attempting to influence the sensemaking and meaning construction of others toward a preferred redefinition of organisational reality“ (Gioia and Chittipeddi, 1991: 442). Research has highlighted the strategic role that middle managers have in creating and distributing understanding of and acceptance for organisational changes. Middle management has to make sense of top management directives, implement and deliver accordingly. Yet, they lack the formal role of authority that top managers have (Rouleau and Balogun, 2011). “Top management provides important details about the change, while middle managers are left to construct their own meaning of it, and therefore play a crucial role in how change ultimately gets passed on to front line employees” (Maitlis and Sonenshein, 2010: 559). For example, scholars have addressed the way middle managers interpret and communicate strategic changes (Rouleau, 2005) and how middle managers´ use discursive competences when implementing organisational changes (Rouleau and Balogun, 2011). Discursive competences here concern how individuals are able to craft and disperse their message in order to influence the meaning making of others. It is not just about the language that is used, but also how the language is adjusted and used in specific contexts with specific stakeholders (Rouleau and Balogun, 2011). The ability to tell the right story at the right place for the right people is thus a key to influence others (Maitlis and Lawrence, 2007). Based on two studies of middle managers’ practices in change situations, Rouleau and Balogun (2011) developed a framework of discursive activities that are applied by middle managers in sensemaking processes, see Figure 1.

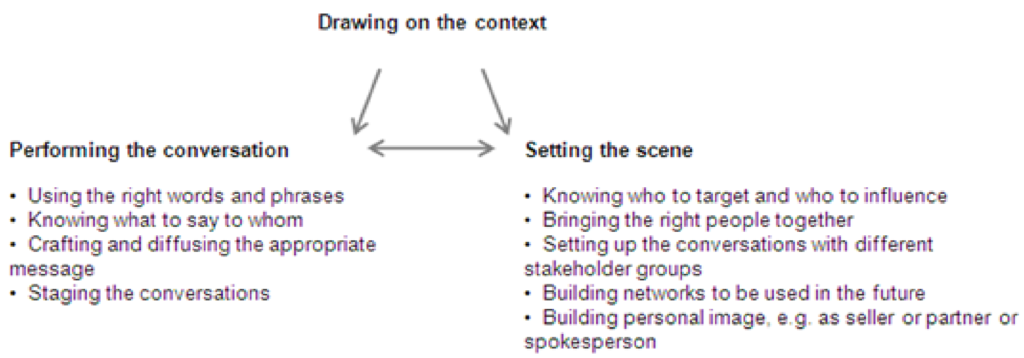

Figure 1: Discursive activities applied by middle managers in sensegiving processes (Rouleau and Balogun, 2011: 972)

Rouleau and Balogun identified two main sets of activities that middle managers use in order to influence other stakeholders' sensemaking. First, middle managers perform the conversation with stakeholders. This activity is described as the "multiple interactions middle managers engage in through formal and informal conversations with their peers, subordinates, superiors, and customers or other stakeholders, to draw others into their agenda" (Rouleau and Balogun, 2011: 958). The second activity regards how middle managers are setting the scene, which is described as "what is done to set up the context for, background to, and occasion for the conversation performance" (Rouleau and Balogun, 2011: 958). The success of both sets of activities are dependent on how well the middle managers can draw on the context, which means how well they understand and make use of contextual factors, such as history and knowledge of stakeholders, context specific rules, language and terminology. The study by Rouleau and Balogun (2011) thus suggests that middle managers need be aware of organisational politics and act politically in order to engage in sensegiving. This means that whom is given the opportunity to influence the surrounding depends on how well that person can translate and apply contextual knowledge and discursive competences, rather than formal power received by hierarchical position. Moreover, Maitlis and Lawrence (2007) studied conditions that trigger and enable sensegiving activities. Based on their study of three British symphony orchestras, Maitlis and Lawrence propose that actors are more likely to engage in sensegiving when they possess issue-related expertise and/or legitimacy as well as when provided with the right opportunities. Further, what triggers an actor to influence how others understand an issue relates to whether the issue at stake is perceived as important for him/her, for his/her colleagues and/or for the whole organisation. Drawing on Rouleau and Balogun (2011), it is possible to unfold and when actors, such as the energy expert in our case study, make use of discursive competences in order to influence the organisational interpretation and management of the energy target in the organisation.

3. Method

The paper is based on data gathered in a research project carried out between December 2010 and August 2011. Focus of the study was organisational actions triggered by a political directive to significantly cut the energy use in buildings managed and operated by a public construction client organisation (here called Alpha). Taking a narrative approach, the story of how Alpha made sense of a political directive is based on interviews, field observations and written documents. This explorative, longitudinal study, posed an opportunity to study how meaning was made over time and how it was contextualized. The full empirical data set consists of observations of 13 project meetings, various documents, in all 25 interviews and extensive field notes. However, for the purpose of this paper a subset of the empirical data has been used. The subset of data consists of in-depth interviews with seven people and a focus group discussion. One of the respondents, an energy expert at Alpha, was interviewed at eleven different occasions covering the whole study period. Applying a thematic interview approach, six additional actors were interviewed once and encouraged to narrate: (1) activities and decisions taken in order to investigate implications from the target and (2) the energy target. The additional actors included three members of Alpha's Management Team and three actors that became involved in an investigation project of implications from the target. The interviews lasted for one to three hours each. All interviews were recorded and transcribed in verbatim. More, during one of the project meetings the first author of this paper was given the opportunity to hold a discussion that resembled a focus group (Bryman, 2008). The first author presented the identified actions taken during the investigation of the implications from the energy target and gave an account of main events and decisions in chronological order. During this presentation, four of the respondents discussed and elaborated on what had actually happened during the process, thus enhancing their own sensemaking but also helped verifying the research results. The discussion was recorded and fully transcribed. The analysis has been an iterative process altering theory with empirical data (cf. Langley, 1999, Dubois and Gadde, 2002) which has made it possible to identify and understand organisational sensemaking within the organisation. Identified characteristic and/or events have been analysed by applying the framework in Figure 1. The study presents a retrospective account for these events since they occurred before the starting point of the study (in December 2010). Accordingly, the story presented is based on the respondents' retrospective narratives.

4. The story of how Alpha made sense of a political directive

The studied organisation, here called Alpha, is part of a Swedish public county organisation which is governed by democratically elected politicians. The county organisation provides "the prerequisites for good public health, a rich cultural life, a good environment, jobs, research, education and good communications". Alpha was formed in 1999 when four regional districts merged into one and today Alpha owns, rents and manages public facilities such as health care buildings, museums and other public premises. More than 80% of Alpha's energy use is related to operation and maintenance of nine large emergency hospitals. Several of these hospitals were built between the years 1950-1975, and both the buildings and the technical systems of the buildings are now reaching the end of their technical life span. More, the operation of care has changed over time, which put new requirements on the premises. Accordingly, these buildings are in need of major refurbishment. In addition, new health care buildings are planned or under construction. The story told here took off in early 2010. This was at a time when the politicians discussed how to formulate the target, but before it was officially launched in Alpha. The story ends with an event day in autumn 2010, called the Energy Day, which contributed to the organisational sensemaking of the target in several ways. The time frame and some key events in the story are illustrated in Figure 2.

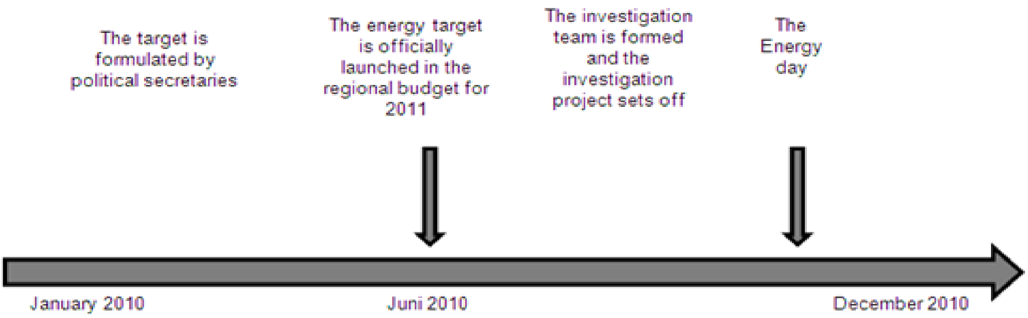

Figure 2: Time frame and key events

4.1 The story voices

In the story of Alpha, we give rise to different voices in order to understand how different actors develop a mutual understanding of the political energy directive as well as to how they influence people in their surroundings to adopt their view. Thus, the key characters in the story need some presentation. The most central character is ***Mr Energy***, who has an engineering background and has been working at Alpha since it was formed in 1999. He is part of Alpha's R&D department and is formally responsible for development of work practice regarding operation and maintenance of buildings and energy issues. He has thirty years of experience within this field, and has executed several successful projects and initiatives related to reduced energy use in buildings. In his daily work, he spend a lot of time on networking, both inside Alpha and externally and he puts high value in having a rich personal network. Other respondents in the study witness that 'everyone' have great confidence/trust in him and that he is seen as 'Mr Energy', i.e. the energy expert, in Alpha. Other important characters in this story are three (out of eight) members of the Management Team, i.e., the ***General Manager***, the ***R&D Manager*** and one ***District Manager***, DM; as well as an external ***Energy consultant***. All four have an engineering background. The GM, the R&D manager and the DM have been working for Alpha since it was formed. Other respondents describe the GM's leader style as consensus driven. The R&D manager previously worked as a district manager, but has been in his current position for some years. Mr. Energy described the DM as a 'locomotive' when committed to something, which is reason why he became involved in managing the energy target. All three members of the Management Team are supporters of energy efficient measures. The fourth character is the Energy consultant. He is described by others as a driving spirit and entrepreneur in the energy efficiency area and for several years Alpha has been a major client for the consultancy firm he is partner in. Two groups of officials that are also part of the story are the Regional Secretaries and the Environmental Department. The Regional Secretaries support the political parties in for example preparing proposals and basis for decisions. The Environmental Department is a 'sister organisation' to Alpha, with responsibility for general environmental issues in the count organisation. These groups of actors play an important role in the initial phase of the story. However, they were not included in the case study setup, i.e. they have not been interviewed.

4.2 Facing a new target

In the beginning of 2010, as a consequence of the new national directives on energy, the Regional Secretaries were about to formulate the energy target for buildings on demand from the county politicians. At the time, officials at the regional Environmental Department who cooperated on a daily basis with Mr. Energy and shared an agenda for increasing the energy efficiency in the region, promoted him as ‘the expert to talk to’ regarding energy targets for buildings. Thereby, the officials in the Environmental Department set the scene for a dialogue between the politicians and Mr. Energy and thus, they made use of his expertise to strengthen their case; *“You can say that the Environmental Department took help of me when it came to the energy demands for buildings, through initiating the dialogue between me and the politicians.”* The fact that the officials at the Environmental Department saw him as a spokesperson for energy issues further increased his influence in the dialogue and strengthened his reputation as an energy expert in the region. The first contact between the Regional Secretaries and Mr. Energy was taken after a political meeting. As a consequence, they initiated a dialogue that lasted until the formulation of the target was set. However, according to Mr. Energy the Regional Secretaries did most of the talking while he took on a rather passive role and the GM stayed inactive and just listened. Mr. Energy recalls; *“The GM and I presented an issue for the Regional [political] Board, when a Regional Secretary grabbed me and asked to talk to me. She presented how they intended to write [regarding the energy demand] and asked if they had missed something. During this time, the GM just stood there and listened. [...] I felt that the GM had great confidence in me. He laughed and said ‘It is really good that you take responsibility for this, otherwise it would have become a mess’. So, he [GM] knew more about this [issue] than most of the others [in the organisation].”* Since the GM did not intervene in the dialogue between Mr. Energy and the Regional Secretaries, he gave Mr. Energy his passive support and the opportunity to use his expertise in the formulation of the energy target. This support was important for Mr. Energy, as he knew that the benevolence of the Management Team would be crucial for a successful implementation of the new target. Moreover, with Mr. Energy as an expert in the target formulation process, the GM certified that it was ‘crafted appropriately’. In the dialogue, Mr. Energy drew from earlier experiences of implementing energy efficiency measures at Alpha in order to guide the Regional Secretaries to avoid the most troublesome formulations. He used the opportunity to craft the message to be more appropriate, i.e. certify that the formulation would be beneficial for Alpha and the whole region. According to Mr. Energy the dialogue with the Regional Secretaries was informal and off the record. For him, it was vital that his colleagues at Alpha did not see him as the driving force behind the energy target. Instead, it was important that the target was viewed as the ‘work of the politicians’ as it gave the new target the needed legitimacy. For Mr. Energy, this dialogue was an opportunity to set the scene for an increased energy focus at Alpha. Informally, he was also very careful about keeping the GM and the R&D Manager informed and therefore he discussed energy issues with them on a regular basis.

4.3 “Then he put his foot down”

Several respondents (i.e. the GM, the R&D Manager and the DM) independently gave a similar picture of what happened when the rest of the Management Team heard about the target for the first time. During spring 2010, the GM invited a Regional Secretary to the Management Team for an information session regarding the forthcoming energy target. The reactions from the Management Team members were diverse, where especially the district managers expressed the most cautious attitudes. The DM, for example, questioned the Regional Secretary about the background of and details about the target. When the secretary did not have all the answers ready the DM became sceptical and therefore, the DM's reaction to the energy target was to consider it as 'a passing fancy' from the politicians. By the time for the information session, the GM had already understood and accepted that an ambitious target was coming up, during regular discussions with Mr. Energy. He had also made up his mind on how this target should be approached by Alpha and during the session he made his standpoint clear to the rest of the team, stating; *"If the politicians set a target that we should meet…Well, we take it as a compliment that they set such a tough target, because it signals that they believe in our capabilities!"* The GM told them that the target was not negotiable; it was a demand from the politicians and should be treated as such. By this statement, he set the scene for the Management Team and did not allow for any other positions; *"The reaction was that 'Now we must devote every effort to change the politicians´ minds because they are off track completely'. Well… then [the GM] put his foot down and said that 'this is an owner demand and we just have to adjust to it'."* This forceful exclamation, as described in the citation by Mr. Energy, shows that the GM wanted to give a clear message to his team, i.e. that they had to adopt the target and adjust to the new situation. Furthermore, this statement by the GM was important for Mr. Energy's forthcoming work of implementing the target in the organisation, and he often retold this story in conversations with colleagues to emphasise that the target was legitimised by the GM.

4.4 Preparations for an Investigation

During summer 2010, through continuous discussions with the GM and the R&D manager, Mr. Energy convinced them that the consequences of the energy target for Alpha needed a thorough investigation, focusing on opportunities and threats.Mr. Energy was very well aware of whom to direct, namely the Management Team, and what to tell them, that the energy target must be taken seriously. Hence, he paved the way for the Management Team to allow him to develop and implement a strategy to meet the new target. These preparations were a way of setting the scene for an Investigation project aiming at facilitating for Alpha to meet the target. After summer 2010, the GM approved that an Investigation project regarding the consequences of the energy target should be conducted, appointed Mr. Energy the assignment and gave him full responsibility for it. By giving Mr. Energy 'free hands' to design and conduct the Investigation project he was made responsible for formulating the task description including setting budget and defining scope and goal of the Investigation project. There did not seem to be any doubts among the Management Team members about giving one single actor, Mr. Energy, such a large responsibility. On the contrary, the R&D Manager gave this view, when asked about it:*"I am not worried about that. It is all about the person. Personally, I have great confidence in [Mr. Energy]. We have worked together for so many years now. […] I know that if there is something he is unsure about, whether or not he has the mandate to do something, he´ll turn to me. And he knows that I want him to take initiatives without asking me for permission. Accordingly, if he would be barking up the wrong tree I have to back up for him. He doesn´t do that but if he would, I am responsible if something goes wrong. The whole organisation trusts in him. These [energy] issues are close to his heart. He has a large network; he cares for his contacts with universities and trade organisations. He uses his network to secure that he is on the right track."* Also the GM appreciated Mr. Energy as Alpha's spokesperson and driving force for energy issues, calling him 'our Energy man' and also arguing why he was given the task by saying that the organisation is *"lucky to have someone that suitable, to do this kind of work"*.

4.5 Forming a team

Once given 'free hands' to set up and conduct the Investigation project as he liked, Mr. Energy started to form a team that could assist him in the Investigation. For Mr. Energy, the personal network and individual relations were essential and, as he stressed in an interview, he considered the personal attributes, interests and characteristics more important than titles and organisational belonging. Thus, he searched for enthusiastic driving spirits with specific competences when forming the team for the Investigation project. He soon identified the Energy consultant as a beneficial partner. Mr. Energy and the Energy consultant had met a few years earlier in one of Alpha's investment projects, where they worked together in a team they both described as creative and engaging. This work led to them to conclude that there was a 'strategic gap' between building plans and how plans should be realized in Alpha. That is, they lacked a strategy for how the building plans should be implemented. According to the Energy consultant, the current situation, with a political set energy target but no strategy yet for how to meet the target, was similar. Furthermore, Mr. Energy knew that the Energy consultant earlier in 2010 had been engaged by Alpha to design plans for a new hospital building, a work that resulted in significantly lower energy use than for conventional buildings. Together, these two aspects made the Energy consultant an attractive and inspiring partner in the Investigation team: *"I knew [the Energy consultant] to some extent and had been working with him in a previous project. So I knew that we had been able to talk to each other very well… It was the same instinct feeling that I felt before […]. I was not interested to start working with someone if that collaboration resulted in a lot of hard work. It was very much a matter of personal chemistry..."* The others in the team were for example junior consultants form the consultancy firm and an Alpha Real Estate Economist. By choosing people he enjoyed cooperating with, Mr. Energy set the scene for conducting the Investigation project in his own way. According to the Consultant, Mr. Energy already at this moment knew what result he wanted from the Investigation. However, he needed support to achieve his goal; *That was what [Mr. Energy] said: 'I want to [get the energy efficiency work going], but we need to phrase it in a way so that we get an assignment'. By then the target [to reduce energy use by half] had been launched. 'How do we do this?'* [...] *Mr. Energy called me and asked: 'Are you interested to join this team?' Of course! It was kind of the most exciting thing to do. It was me, [a junior consultant colleague] and [Mr. Energy], and we had no clue of where this would end...*.Thus, this early composition of an Investigation project team had a vision of what they wanted to achieve with the Investigation, but how to reach that goal was open-ended.

4.6 The Energy Day

As described above, Mr. Energy experienced that the Management Team's attitude towards the target became positive during summer 2010, after the GM´s action to 'put his foot down'. On the other hand he also noted in informal conversations with colleagues, that the general opinion in Alpha was rather sceptical towards the target. He was familiar with a large share of the employees, due to his formal role at the R&D department, his long history in the organisation and his outgoing personality. He had regular contacts with for example project leaders, operation and maintenance personnel regarding energy issues in general and during this particular time, the new energy target in particular. Early autumn 2010, Mr. Energy masterminded an 'Energy day' where all employees at Alpha were invited to participate. By inviting all employees, Mr. Energy wished to create a positive spirit regarding energy efficiency. However, the invitation was on Mr. Energy request sent out by the GM, and Mr. Energy deliberately made sure that he and his energy-dedicated colleagues did not appear as key players of the day. Now, the Management Team should be seen as the leading partner and the one sending out the message to the organisation. The Energy day was initially planned to take place during spring 2010, but Mr. Energy chose to postpone it until the target was officially launched. Headline of the day was *"See the opportunities and rise to the challenge!"* and it was in detail orchestrated by Mr. Energy. Not only did Mr. Energy initiate the Energy day, he also set the agenda and invited the speakers, thus he set the scene completely. Drawing on earlier experiences of how important the Management Team's commitment was for successful implementation, Mr. Energy stressed the importance of having the Management Team on stage; *"When I presented the agenda of the day to the Management Team, I told them that I would not be in the limelight that day. I have arranged the day and I have put your names on the different presentations. And then they looked at me and asked: 'Can't you do it, because I don't know this properly? Can't you make the presentation instead?' No, I said, I will help you, I will prepare the presentation for you, I will do everything for you, but I won't present."* As put forward by one of Mr. Energy's colleagues at the R&D department and member of the Investigation team*: "This is what has been missing [before]. Mr. Energy has been on the barricades and then we have been a few that have supported him and occasionally been on the barricades. But we have lacked the Management Team's [commitment]."* Mr. Energy described how he experienced the Energy day; *"I think it was important that the [staff] saw that it was the Management Team that brought the message across. […] We had people from the National Energy Agency here and we had other external guest presenters. In the afternoon we had our own people presenting different examples and we talked about how to meet the new demands. And then [the staff] probably realized that this is something that pervades the entire society. This is taken seriously! And since that day things have actually changed continuously. In fact, today I think everyone is on track on this."* Hence, the Energy day was an important event for the organisational sensemaking in several ways. Firstly the target became everyone's business. To accomplish this, Mr. Energy made sure to invite people from all parts of the organisation, not only those who were directly involved in energy use in buildings. Secondly, the renewed focus on energy became legitimised by the presence of and actions by the Management Team. By insisting on presentations by the Management Team, these became more prominent during the day, sending the message to the employees that that this was something the management supported. As such Mr. Energy triggered a sensemaking process within the organisation.

5. Discussion and concluding remarks

This paper aims to contribute to our understanding of how an EU directive on energy use in buildings diffuses into and is managed by a public construction client organisation. We take a micro-perspective in our story of how the actors made sense of an energy target and its implications. We have examined how discursive competences were deployed as means to influence the organisational sensemaking of the target initially. Using a narrative approach, we have accounted for the talk, action and interaction between mainly the energy expert, the Regional Secretaries and the Management Team in order to examine how the sensemaking of the target progressed.

It is clear from the empirical account that Mr. Energy had a most distinguished role, sanctioned by the GM, in the organisational sensemaking process. Mr. Energy made use of his experiences, his own networks and his communicative skills in order to manoeuvre the organisation in the direction he found beneficial for the organisation. As acknowledge by Rouleau and Balogun (2011) an effective strategic player is characterized by *"their ability to relate and engage in a way meaningful to those they seek to influence and lead"* (p. 977). This description fits well with Mr. Energy. Not only did he contribute to, but he also guided the organisational sensemaking of how the challenge posed by the target should be managed by the organisation. He did this by deploying discursive competences, such as crafting an appropriate message, knowing whom to influence and how to communicate with different stakeholder groups. These are all examples of discursive competences presented in the framework of Rouleau and Balogun (2011). Energy efficiency was one of the top topics on Mr. Energy's personal and professional agenda. However, he experienced that the organisational focus on energy had been lost over the last years. Therefore, he could use the political target to legitimise an increased focus on, and create commitment for, energy efficiency. This confirms what Maitlis and Lawrence (2007) found regarding what triggers and enables stakeholders to engage in sensegiving activities. What enabled Mr. Energy to influence how the organisation made sense of the target was that he had expertise knowledge in the area and that his actions were legitimised by the Management Team. Further, he was triggered to engage in sensegiving since the political set target was in line with the energy efficiency work that he had strived to implement for many years in the organisation. One could even say that the political target came as a spark to his fire and fuelled his motivation for the issue further. In spite of these good prerequisites, Mr. Energy still made sure that he had the support and goodwill of the Management Team during the sensemaking process. He continuously anchored his understanding and reflections regarding the new target with the GM and the R&D manager, as they had the most strategic roles regarding energy management strategies and practices. This way he certified that they understood and supported his interpretation of the target and took the formal responsibility. Talking and acting along the informal decision routes, he anchored his work the formal way. Thus, he executed the power he had in the role of an appreciated energy expert.

The aspect of how power is executed and maintained has not been in focus of this paper, but power issues are sensed in the way Mr. Energy acted to guide the organisation. Hence, this confirms what for example Weick et al. (2005) and Maitlis and Sonensheim (2010) have noted, namely that power in sensemaking and sensegiving is an issue that needs further examination. Maitlis and Lawrence mean that narrative studies can provide a powerful way of exploring how power and politics influence sensemaking in organisational change. Mr. Energy´s power to influence is for example shown in how the Management team gave him free hands to influence, investigate and define an issue that was of high strategic relevance for the organisation. However, as seen in the empirical account, Mr. Energy was also dependent on that other people saw him and presented him as an expert. Initially, we learnt how others, more precisely the Environmental Department, set the scene for him to craft an appropriate energy target for the region. Without their intervention, Mr. Energy would probably not have been invited to assist the Regional secretaries with the formulation. Later on, we learnt how the general manager and the R&D manager set the scene for Mr. Energy to conduct an Investigation of the organisational consequences of the target. They allowed him full control and 'free hands'. In their explanation of why they let him work so independently, they gave explanations in terms of trust, confidence and appreciation. In the accounts presented here, Mr. Energy benefit from that others set the scene for him to perform the conversation and thereby influenced how sense should be made. The observation that an expert, in our case study the energy expert, was enabled to engage in sensegiving processes since other people set the scene for him/her can be seen as a contribution to Rouleau and Balogun's (2011) framework of discursive activities applied by middle managers in sensemaking processes. In conclusion, the expert role can be described as a 'sensegiving agent'. Using his/her discursive competences, he/she manoeuvres the organisational sensemaking in the way he/she sets out. But the manoeuvring needs to be enabled by tacit and/or active support from top management and other organisational actors. Thus, more research is needed to unfold the role of the sensegiving agent in strategizing processes.

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Cognitive interests, epistemological space and aspirational identity: how does identity form part of construction?

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Abstract

The concept of 'identity' has been relatively unexplored within the discipline of construction and questions as to how identity forms part of organisational practice remain novel. Identity is often defined as the distinctive character of any given individual or the specific dispositions shared by members of a social group. More specifically, it refers to a sense of selfhood; it is an expression and a conception of how individuals or groups affiliate and it reflects a sense of being and belonging. Identity presents a set of generating and structuring principles, dispositions and structures of perceptions that guide action and practice. Practitioners will influence, and be influenced by, the nature of actions-interactions and the discursive practices of their organisations. It is argued that the epistemological nature of the space within which practitioner actions-interactions occur is critical in the development of identity. Moreover, the epistemological position(s) that scholars assume is salient in the narration of the socially constructed identities.

In this paper we consider the concept of identity and relate it to construction industry through three key approaches: first, drawing on Jürgen Habermas'(1972) theory of knowledge and human interests, we consider how individuals' identities can be characterised by their cognitive interests—technical, practical-hermanutic and emancipator—and how managers in the construction industry display distinct social behavioural traits akin to their cognitive interest; secondly, we couple the notion of cognitive interests with Martin's (2002) three cultural perspectives—integration, differentiating and fragmentation—and explore how these may be perceived as three distinct epistemological spaces that represent a robust discursive framework for the study of socially construed identities; and, thirdly, we explore how, through the concept of epistemological spaces, propositions on the 'aspirational identity' of practitioners can be constructed. Through this paper, we argue that the concept of identity represents a useful analytical approach for exploring issues related to agency, interaction and discursive practice, and that it can support the study of organisations as socially constructed realities, subsequently stimulating further insights into the social dynamics that form part of, and influence, the practice of construction organisations. The paper also identities how this framework can be used in future research work on identities in construction.

Keywords: Identity, project organisation, cultural perspective, cognitive orientation

1. Introduction

The theoretical concept of 'identity' is relatively new to the field of construction management and questions as to how identity forms part of organisational practice remain unexplored territory (Brown & Puha, 2011). Identity is often defined as the distinctive character of any given individual or the specific dispositions shared by members of a social group. More specifically, it refers to a sense of selfhood; it is an expression and a conception of how individuals or groups affiliate and it reflects a sense of being and belonging. Identity presents a set of generating and structuring principles, dispositions and structures of perceptions that guide action and practice. As such, the concept of identity represents a useful analytical perspective for exploring issues related to agency, interaction and discursive practice, and it can support the study of organisations as socially constructed realties (Ybema et al., 2009).

Identity has been explored in relation to organisational control (Alvesson & Willmott, 2002; Willmott, 1997) and different forms of identity—including personal identities, managerial identities and social identities—have been examined (Watson, 2008). Identity sustains a fundamental bridge between different levels of analysis of socially constructed realties—individuals and collective units including groups, organisations (Ybema et al., 2009)—and, as such, it represents a critical element for the development of a holistic understanding of life. Research into identity explores the distinctiveness of individuals in social settings (Alvesson, Ashcaraft & Thomas, 2008) and enables further understanding of the dynamics between individuals, groups, communities and social fields (Knights & Willmott, 1987; Alvesson, 2002; Smircich, 1983).

The dynamic interplay between individuals and their social settings illustrates the intertwined nature of individual agency and organisational culture. Within the social sciences, the link between the individual agent and their social setting is emphasised in the search for a boarder understanding of socially constructed realties and it is perceived as a critical constituent in research concerning subjectively constructed identities (e.g. Bourdieu, 1977; Ortner, 1974; Giddens 1984). This is because, although it is broadly agreed that culture and identity represent subjectively constructed realties, these realities emerge through participation in and engagement with pre-existing (yet dynamic) social structures, which may be considered as objective realties. Ybema et al. (2009, p. 303) argue that a multiplicity of situational factors will influence identity formation and that 'social identities can be theorized as the refracted articulation of agency and structure, playing out in different forms in different discursive domains and temporal spaces'.

Identity can be used as a novel, interpretive approach to analyse organisations. Identity—whether referred to as subjectively available self-narratives (Clarke, Brown & Hailey, 2009), as a dynamic and continuously changing sense of coherence and distinctiveness (Alvesson & Willmott, 2002), or as subjective meaning and experience (Alvesson, Ashcraft & Thomas, 2008)—represents a theoretical concept that allows exploration into issues such as: meaning making; groups and boundaries; engagement, motivation and commitment; and, agency and practice. According to Brown and Phua (2011) understanding the role of identity and 'self' is central to the task of construction managers of project organisation. They suggest that people in construction organisations develop a sense of self through reflection of cultural artefacts, interaction and communicative practices. This is a complex process founded upon an intricate interplay between power, social and institutional structures, which blurs the boundaries between conscious and unconscious engagement in identity development (Bucholtz, 1999) and poses questions as to whether or not a person's identity represents a unified whole. The latter point is recognised by Alvesson, Ashcraft and Thomas (2008) as one of two key concerns related to identity. They argue that identity is problematic, firstly, in relation to its durability and, secondly, in regards to its integrated or fragmented nature;, whilst they assume the 'presence of multiple, shifting and competing identities', they also question how in particular situations 'identities may appear orderly and integrated' (Alvesson, Ashcraft & Thomas, 2008, p. 6).

This multiplicity and the blurred associations between the objective and subjective realities (dualism) can pose significant challenges in developing meaningful discursive narratives warranting new kinds of subjectivism (Deetz, 2003). For example, how are industry structure, legal structure and project structure embedded in objectively or subjectively constructed realities? What impact will this have on personal identities and group identity? These questions have bearings on construction organisations and addressing the dynamic between objective structures and subjective realities can provide important insights into the social dynamics that form part of, and influence, practice and interaction within and between construction organisations. Through a review of existing scholarship concerning two particular theoretical positions, namely Habermas' (1972) cognitive interest theory and Martin's (2002) cultural perspective theory, this paper considers these questions and aims to provide a framework for understanding the role of identity in construction organisations. The paper outlines Habermas' concept of 'cognitive interests', relates it to Martins' (2002) cultural perspective theory and, subsequently, establishes the concept of three epistemological spaces—'integration-technical', 'differentiation-practical' and 'fragmentation-emancipation'. This is followed by an exploration of how epistemological spaces manifest within project organisations through the actions and interactions of practitioners. It is argued that the epistemological spaces provide structures for relationships that are salient for the development of identity, including the formation of the 'aspirations identities' of practitioners; that is, they provide a lens with which the discourse of aspirations identities can be interpreted and connections between identity and practice can be made.

2. Discourse of 'identity' through epistemological spaces

2.1 Identity and cognitive interests: Habermas' social theory

Held (2001, p. 402) writes in his introduction to Habermas' theory that '[t]hrough an assessment of the self-formative processes of the human species, Habermas's critical theory aims to further the self-understanding of social groups capable of transforming society'. One of Habermas' fundamental concepts is that of 'cognitive interests', which represents his first attempt in specifying the relationship between knowledge and human activity (Held, 2001: 404). Since it was first introduced in the publication *Knowledge and Human Interests* (Habermas, 1972), the theory of cognitive interests have been adopted and critiqued by a number of scholars from a range of disciplines, including education and cultural analysis (e.g. Alvesson, Ashcraft & Thomas, 2008; Willmott, 1997). It is not our intention in this paper to provide a comprehensive analysis of Habermas' theoretical framework, its development, influence and critique. Rather, we explore how the concept of cognitive interests has been adopted by authors such as Willmott (1997) and Alvesson, Ashcraft and Thomas (2008), and how it is used to explore processes of self-formation.

In short, Habermas' theory of cognitive interests is an exploration of the conditions for the possibility of knowledge. Habermas emphasises the role of historically positioned cognising subjects who constitute knowledge from the basis of their historical material conditions. He argues that humans organise their experience is organised in terms of *a priori*—'basis'—interests' that reflect their technological and linguistic nature. Humans have an interest in 'the creation of knowledge which would enable it to control objectified processes and to maintain communication' (Held, 2001, p. 403); they have *technical* and *interpretive* interests that reflect the needs to 'produce from nature what is needed for material existence [...] and communicate with others through the use of intersubjectively understood symbols' (Held, 2001, p. 403). In addition to these interests, humans have, according to Habermas, an interest in the reflective appropriation of life, in self-reflection, self-determination and rationality. Such knowledge generates autonomy and responsibility and is conditioned by an *emancipatory* interest.

The three different cognitive interests are associated with a particular type of scientific inquiry and have become associated with different approaches to learning. Subsequently, they are often spoken of as different 'identities', reflecting different dispositions—instrumental, practical or emancipator—to practice and knowledge. Willmott (1997) explains that technical cognitive interest is based on a rational instrumental approach for understanding actions-interactions, knowledge generation and problems solving in social spaces (e.g. organisations, groups, projects etc). It is driven by the 'empirical-analytic science', which intends to calculate and remove all forms of formal irrationality to enhance prediction and control of functions in socially constructed realties. Individuals driven by this cognitive interest will focus on identification and manipulation of social variables that is perceived to impact some form of performance agenda, they will hold a positivist world-view and believe that social spaces can be calculated and controlled. A person displaying an identity underpinned by this cognitive interest will often assume that ambiguities in the social setting can be eradicated through removing irrationalities and, as a consequence, deny ambiguity (Alvesson, 2002).

Practical-hermeneutic or interpretive cognitive interest contests the ideas of attaining effectiveness through manipulation of social realities. This cognitive interest, which is driven by the interpretativist approach, focuses on "symbolic communication" to remove "misunderstandings" (Willmott, 1997) in social spaces. This fosters an understanding of 'how to achieve common interpretations of situations so that coordinated action is possible' (Smircich, 1983: p. 351). The identities driven by practical cognitive interests generally support the idea that developing an *appreciation* of the meanings, symbolism and ideas within social spaces can assist in removing unnecessary misunderstandings and assume that ambiguities in social spaces can be dealt with through communicative action (Alvesson, 2002).

The emancipatory cognitive interest is based on 'critical science' and intends to develop more rational social relations' through social realisation (Willmott 1997: 317). Willmott (1997) explains that identities underpinned by this cognitive interest tend to seek to expose any form of domination and exploitation and remove any unnecessary suffering in social spaces. Individuals holding such cognitive interest will generally aim to enlighten other members in their social space about the exploitation and domination they endure, and subsequently transform the way they operate. The main focus of the emancipatory approach is to understand the negative features of social spaces, by deciphering the taken-for-granted actions and interactions. Through critical reflection, individuals holding an emancipator interest will be able to understand irreconcilable tensions in social spaces (Martin, 2002), subsequently acknowledging the existence of ambiguity as a normal and salient part of social space.

On the basis of this theoretical framework, it can be presumed that, in relation to the construction sector, practitioners and managers will hold different identities that reflect their cognitive interests and that their professional background and practice will vary accordingly. Whilst the question of how these factors influence practitioners in forming their identity is beyond the scope of this paper, the subsequent sections will explore how cognitive interests form part of epistemological spaces that influence socially constructed identities.

2.2 Identity and social spaces: Martin’s three cultural perspectives

According to the framework outlined above, the three cognitive interests will support particular interpretations and understandings of action, interaction, knowledge and problem solving in social spaces, such as organisations, groups and projects. In the context of this paper, we consider social spaces as cultures (Alvesson, 2002; Burrell & Morgan, 1979; Smircich, 1983); that is, as particular social constructs that are determined not by their cultural artefacts but by the abilities, notions and forms of behaviour that is acquired through membership in a social setting. Martin (2002) offers three cultural perspectives that can be used to analyse social spaces, namely ‘integration’, ‘differentiation’ and ‘fragmentation’ (see also: Meyerson & Martin, 1987). These three perspectives reflect, firstly, how members in a social space deal with ambiguity and, secondly, how they share cultural manifestations, such as values, beliefs and symbols, within a social space. That is, social spaces can be categorised according to the extent of harmony, paradoxes and conflicts that arise through the acceptance or rejection of ambiguity and common cultural manifestations. This argument can be aligned with Habermas’ three cognitive interests; an interjection that may provide an interesting epistemological platform for discussion of socially constructed phenomena. In the purview of this paper the proposed ‘epistemological spaces’ created by the dynamic interplay between the characteristics of the social space and cognitive interest is used to inform the discursive practices relating to the practice and research on identity.

According to Martin (2002, 2004), *integrated* social spaces embody consistency in relation to cultural manifestations and there will be a general consensus on issues amongst all members of the social space. Various levels in the social hierarchy display similar viewpoints and cultural expressions within the space will be monolithic, integrated and homogeneous. Due to the harmonious nature of the social space, any form of ambiguity is eliminated. Identities consumed in an integrated space reflect a commitment to organisational control, work ethic and organisational effectiveness. It can be argued that integrated social spaces will be dominated by actions and interactions driven by ‘technical’ interest, due their intent to calculate and remove formal irrationality and create consensus within the social space. For the purposes of the later discussion, this space is called the 'Integration-Technical epistemological space'.

Whilst integrated social spaces are characterised by consensus, *differentiated* social spaces reflect both consistency and inconsistency among cultural manifestations. That is, consensus will exist within groups or section of the social space but not between them and, as a consequence, disagreements between members of this space will be emphasised. Although ambiguity is acknowledged, it channels it to outside sub-cultures (for example, in relation to construction projects, architects may channel ambiguity to contractors and vice versa). Identities consumed in a differentiated space will support some level of control within sections of the group, which may limit some ambiguity, however misunderstandings are inevitable between social spaces. It can be argued that differentiated social spaces will be dominated by action and interaction driven by 'practical-hermeneutic' interests, due to a focus on symbolic communication (aimed at the removal of misunderstandings). For the purposes of the later discussion, this space is called the 'Differentiation-Practical epistemological space' (Martin, 2002, 2004).

In contrast to integrated and differentiated social spaces, a *fragmented* social space is characterised by lack of clarity, confusion and inconsistency. Cultural manifestations may not be shared by members of the social space, creating paradoxical situations that may lead to conflicts. This space accepts ambiguity as inevitable and it is typically characterised by individuals who believe that dealing with ambiguity is part of business and who makes conscious attempts to remove negative features that arise out the inconsistencies or paradoxes. Fragmented social spaces is more aligned with individuals who hold an emanicpatory cognitive interest and who, as a result, is more open to and able to deal with inconsistency and ambiguity. For the purposes of discussion, this space is called the 'Fragmented-emancipatory epistemological space' (Martin, 2002, 2004; Meyerson, 1991).

Martins' three cultural perspectives and Habermas' three cognitive interests provide the basis to interpret the structure-agency link critical for how identities may support practice. The notion of structure (social space) and agency (driven by cognitive interests) can be used to explore the emergence and theorisation of harmony, paradoxes and conflicts in construction project organisations. The three cultural perceptives and the three cognitive interests offer epistemological spaces for analysis of both individuals and groups (Clarke, Brown & Hailey, 2009).

2.3 Exploring identities in construction through 'epistemological spaces'

It grasping the complexity surrounding identity in the construction domain, it is essential to deconstruct the social spaces of projects and the roles that practitioners in construction projects perform. The key role of a construction practitioner is to ensure that a functional building is delivered through controlling available, often limited, resources; it involves calculation and control of the scope of works to deliver enhance outcomes of design and construction through effective project scheduling, cost control and people management (e.g. reduce disputes) (Brown & Phua, 2011). In assuming their roles, the aspirational identities of practitioners play a critical role in the way projects operate (Brown & Phua, 2011); that is, what role people aspire for within a project and how they wish to be perceived by others will have a critical effect on the discourse of a project. Brown and Phua (2011, p. 90) suggest that ‘research across the social sciences and humanities has long suggested that people work continuously on fashioning preferred versions of their selves’. Therefore, understanding the structure-agency of this discourse, that is the epistemological, has the potential to unravel the complex issues that drive particular behaviours in projects.

Identity is shaped by structural and historical positions of members of a social space. The identity of most practitioners in the construction sector is entrenched in the projects, the permanent organisations and the broader institutional structures (such as professions) within which they reside. Loosely coupled firms in a transient relationship differentiate project organisations from permanent organisations (Dubois & Gadde, 2002; Turner, Huemann & Keegan, 2008). The transient and discontinuing nature of project organisations offers constant opportunities for members to reconstruct themselves to new structural surrounding (Muller & Turner, 2007). Therefore it is imperative that any identity work in construction sector will benefit from situating the ‘self’; that is, placing the managers as agents within the structure of the construction industry and project organisations (Turner & Muller, 2003).

To form loosely coupled project based organisations, firms performing design and construction operations are generally drawn into contractual arrangements that are changing and temporal (Dubois & Gadde, 2002; Turner, Huemann & Keegan, 2008). The principal aim of projects is to organise human and non-human resources to accomplish unique project outcomes that deliver a product, or service, or both (Turner & Munner, 2003). Project organisations are often described as fragmented, something which is perceived as contributing to inefficient work practices (Berggren, Soderlund & Anderson, 2001). Fragmentation in these circumstances commonly refers to the organisational dis-functionalities and misalignments that elements optimal performance (Berggrem, Soderlund & Anderson, 2001; Baiden, Price & Dainty, 2006). Projects are most often characterised by: uniqueness (heterogeneous products and processes), uncertainty, goal misalignment, agency representation, staged operations and boundaries (e.g. structural organisation of professions and functions).

These features directly contribute to project and organisational fragmentation. For example, the uniqueness of each project requires that an account for unknown parameters is created on a project-by-project basis. This contributes to uncertainty in the project environment, which warrants careful allocation of risk among the firms in a project (Lam et al., 2007). Risk perception, on the other hand, is partly driven by procurement/contractual arrangements and by the culture/identity of the project team members. The perception of inappropriate allocation of risks among the firms/team members can lead to the feeling of lack of fairness, which may contribute to further fragmentation between members (agents), with flow-on effects to other aspects of the project (Zaghloul & Hartman, 2003). Moreover, misaligned goals between project members and contracts (Cox, 1996) can create unnecessary boundaries (Usdiken, Soxen & Enbiyaoglu, 1988), bringing fragmentation, ambiguity and conflict to the surface (Meyerson, 1991; Martin, 2002). Based on this narrative, fragmentation entails misalignment of, within and across the structural and agency parameters leading to chaos and conflicts (Martin, 2002).

In lieu of this, overcoming fragmentation and reaching integration is often proposed as an essential function of successful project management. Indeed, the call for integration as a means to enhance project outcomes and improve competitive advantage resonates across the literature in the domains of organisation, information and supply chain management (Fawcett & Magnan, 2002; Baiden & Price, 2011). Ghoshal and Gratton (2002), for example, discuss integration in the context of an enterprise. They identify four important aspects of organisational integration: namely, operational integration (through standard technological infrastructure), intellectual integration (through shared knowledge and information base), social integration (though collective bonds of performance) and emotional integration (though shared identity and meaning). Such diverse forms of integration across both organisations themselves and the project alliances they form, highlight the inherently multi-faceted and complex nature of integration. Based on this narrative, ingenerated environments espouse for consistency and harmony in the agents, excluding, and to a greater extent denying, ambiguity (Martin, 2002).

The above narration of projects as social spaces with different structural and agency arrangements indicate that practitioners can assume an epistemological space and will position themselves in relation to the narratives they construct as agents. This enables identification of how managers—consciously or unconsciously—construct their ‘aspirational identities’ in positioning themselves through different structure-agency practices, which may change depending on contractual arrangements and procurement methods (e.g. construct only, design and build, alliancing etc.). In the following section, we will discuss the possible development of aspirational identities through a theoretical exploration of Martins’ cultural perspective and Habermas’ cognitive interest theory.

3. ‘Aspirational Identities’: The Propositions

3.1 The integration-technical epistemological space

Construction managers occupying the integration-technical epistemological space may argue for an explicit unitary project culture. Based on the theoretical framework presented above, it can be hypothesised that they will seek to develop and extend shared values and systems by focusing on an integration agenda, which assumes that the greater the level of integration across an organisation the lesser the effects of fragmentation. They will see ambiguity as a problem that should be eliminated at every possible level, and that they will use tools to manipulate systems and behaviours with the aim of gaining control of the project through eliminating irrationalities in the construction process (Willmott, 1997).

The ‘aspirational identify’ of a manager in this space will be dominated by calculation and control to deliver project performance: to be able to coordinate and monitor the diverse groups of participants and their operations in a construction project. They will be focused on proposing tools and systems to monitor the progress made towards the achievement of the stakeholders’ goals, specifically complete the project within the predetermined cost, quality and time. Moreover, they will strive for shared expertise and remove any irrational boundaries among different units to predict and control project duration and costs accurately.

3.2 The fragmentation-emancipation epistemological space

It can by hypothesised that construction managers who occupy the fragmentation-emancipation epistemological space assume that the project environments display consistent and inconsistent beliefs, systems and processes that contribute to inherent ambiguity and lack of clarity. Organisations operating in fragmented environments are characterised by contradictions and paradoxes (e.g. through information conflicts, unreasonable risk exposure) that may contribute to unnecessary suffering of members. Projects will have issue-specific consensus, but the overall environment will be dominated by lack of consensus. Managers in this epistemological space are likely to accept ambiguity as an inevitable component of usual business (Meyerson, 1991). They will in most circumstances not hold the view of control and manipulation and will not seek solutions that are only explicitly linkable to performance measures. Rather, they it can be expected that they will support 'emancipation', which is underpinned by the 'critical science' paradigm. This space is about transforming organisations through rational social relations and making people realise their potential (Alvesson & Willmott, 1992).

The epistemological analysis in this space is concerned with the removal of 'unnecessary suffering' in organisations (Willmott, 1997). The aspirational identity of managers assuming this space will be dominated by transforming organisations to provide a better environment for project progress. They will be keen to identify the taken for granted beliefs on the negative features of organisational life and exploitative practices; they will be driven by the desire to develop an understanding of, and to counteract, the taken-for-granted beliefs relating to exploitation and domination of relationships between members, while encouraging them to transform the way they operate. Managers assuming this aspirational identity will focus on grasping the traditional patterns and the repressive aspects of culture whilst liberating the project organisation from its traditional environment. It includes understanding irreconcilable tensions between opposites, sometimes described as ironies, paradoxes, or contradictions (Martin, 2002).

3.3 The 'differentiation-practical' epistemological space

In between the 'integration-technical' and 'fragmentation-emancipation' spaces sit the 'differentiation-practical' epistemological space. On the basis of the theoretical framework it can be hypothesised that the construction managers occupying this space might assume that consistency and consensus (or integration) is possible within some units or groups in organisations but not across them. Existence of ambiguity and misunderstandings is not totally denied in this space, but channel to the interface between sub groups or subculture (Martin, 2002).

Managers in this space may not take an optimistic view as in the 'technical' space, where the assumption is that managers have significant control over issues impacting performance (Alvesson, 2002). Managers are most likely to acknowledge misunderstandings and negotiate these through engagement and communication. The aim of this space is 'to achieve common interpretations of situations [for] coordinated action' (Smircich, 1983a, p. 351), and relates to the removal of misunderstandings among groups to achieve coordinated action. The 'practical-hermeneutic' tradition to studying organisations involves observing and interpreting organisations through 'appreciation' rather than ‘calculation and manipulation’ (Willmott, 1997). The focus of managers will be on addressing communication issues to improve information flows and thereby attempting to reduce misunderstanding. This space is commonly adopted in construction project management (Ochieng & Price, 2010).

4. Concluding remarks

By studying identity and how it underpins practice within construction (project) organisations, it is possible to explore discursive practices between ‘structure and agency’ at differed levels: the individual, group, organisational project and industry. The three hypothetical ‘aspirational identities’ contextualised in the different epistemological spaces illustrate how the concept of ‘identity’ can be used as an analytical approach to explore a range of phenomena in the construction sector, including professional practice, collaboration, communication, claims and adversarial behaviour.

Although the three epistemological spaces, ‘integration-technical’, ‘differentiation-practical’ and fragmentation-emancipation’, are key in positioning various ‘structure-agency’ interactions, it will be an over simplification to assume that each manager’s ‘identity’ will neatly fit into only one of the spaces. The construct of identity is complex and it should be acknowledged that managers would hold multiple ‘identities’ that may be narrated ‘selectively’ based on a particular structural environment. The propositions above can be employed to further explore a number of identity related research areas in construction. It raises questions such as, for example, how does epistemological space form part of particular organisational phenomena—e.g. innovation, collaboration, negotiation and leadership—and, how does the association between objective and socially constructed realities support and manifest as practice?

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“Being a construction worker”: Identity effects as a self-reinforcing mechanism in construction

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Abstract

The interplay between identity and behaviour has been well documented in the literature, but how identity and organizational life relate warrants future research. This paper draws on data from an ongoing longitudinal case study in a large construction company in order to examine how the “self” interacts with the organizational cultural capital. Our results indicate that there exists a strong collective identity that permeates the members of the organization regardless of role, position, and function. We claim that the effect of this strong collective identity is at the heart of an organizational self-reinforcing mechanism that can explain specific traits of organizational life in construction. We conclude by arguing that the identify effect could result in a problematic contradiction between operational “best practices” and strategic “best practices” in construction.

Keywords: identity effects, organizational life, self-reinforcing mechanism, construction

Manager J: *"It is very hard to find a good construction worker and then teach him [sic] how to deal with numbers?"*

Researcher: *"Why don't you find someone that already knows numbers and instead teach them about construction?"*

Manager J: *"That possibility never occurred to me!"*

This short exchange took place during a field observation of strategy away-days (e.g. Hodgkinson et al, 2006) for a group of middle-level managers in a construction firm. They were discussing the difficulty of finding good recruits for strategic positions in the organization. The excerpt illustrates the implicit relationship between the self and culture as composite parts (Hermans, 2001). Here the manager is referring to the wider construct of an industrial culture, construction, and to the self, the identity of those who work within construction; in other words he is referring to his own self identity. To him a "good manager" is a "good construction worker". As many culture scholars, he assumes that cultures are homogeneous, defined by criteria such as place and practice, time and semiotic tools (Hofstede, 1980; Triandis, 1989). Yet, he voices a concern which reflects the challenges of survival in an increasingly globalised world, where boundaries between cultures: national, industrial, or organizational are becoming permeable. This permeability leads to a necessary recombination of existing practices, a form of hybridization (Hermans, 2001; Pieterse, 1995), which in turn creates multiple identities, e.g. a good construction worker who is also competent with numbers, or maybe an economist who has appropriated construction work. Based on findings from an ongoing longitudinal (from 2005) and interpretative empirically-based study of strategy processes and practices in a large construction organization, we explore the relationship between the self and the "construction culture". We argue that the social categories to which people belong have profound impacts on their perceptions of self. Contrary to traditional theories of culture as being something *out there,* we assume that culture exists *in the self* and that there is a continuous interplay and enactment between self and culture. It is this enactment and its implication for construction organizations that we explore in this paper. We have seen that the self and the culture are pulling toward maintaining cultural boundaries rather than allowing for hybridization and change. Using the voices of a large number of managers at different levels of the organization, this paper provides a picture of how the on-site self (i.e. the good construction worker) makes its way into the boardroom (strategic managers) through a self-reinforcing mechanism that we refer to as *identity effects.*

1. Theoretical frame

Humans are flock animals who belong to various social groups or social categories, i.e. cultures. As mentioned earlier, one of the central criteria of a culture is its semiotic system of which language is central. A dialogic approach to self and culture views social languages (discourses of different social groups) as shaping cultural and individual voices. According to Bakhtin there is no such thing as a unique utterance; rather when a speaker voices an utterances he/she ventriloquates, i.e. in his/her utterance are traces of multiple utterances that have been voiced before it; hence Bakhtin's (1973) notion of multi voices (see also Hermans, 2001). Rather than multiple voices or multiple identities, Harré and Van Langenhoven (1991) talk of positions that individuals take on when interacting with others. Discursive action takes place within a specific local moral order of speaking and acting, i.e. within situations bound by specific, where a speaker takes on a certain social position. Taking on a position in a conversation automatically entails that the speaker also ascribes a certain position to his/her interlocutor. For example, a site manager may position a construction worker as willing and able to work overtime whenever requested. Harré and Van Langenhoven contrast social position with an individual's personal position, how the individual defines him or herself and organises his/her life. Thus, the construction worker in the example may contest the social position ascribed him by invoking family responsibilities. The relevance of this discussion to the purpose of this paper is that individual and collective meanings "belong to a cultural capital inherited and invested by new actors through history" (Hermans, 2001). This implies that relationships do not only unfold between people in conversations and enactments with each other, they also unfold within an individual and between individuals and the cultures in which they are embedded.

Self-reinforcement is a conception that is used in many different domains. Within economics, it depicts a process with an accelerating feature: e.g., increasing returns, "earn, earn more" (e.g. Arthur, 1996), production concentration, "produce, produce more" (e.g. Krugman, 1999), or economies of scale "grow, grow more" (e.g. Rostow, 1956). In this sense it portrays a positive feedback. Within the domains of organizational life and sociology, it seems however, to have a slightly different meaning – not necessarily representing any positive feedback (or negative for that matter), but rather as a way to understand organizational behavioral patterns. Edmondson and Moingeon (1998) define organizational self-reinforcement as the process of creating and sustaining organizational routines by the decisions and actions of individuals. Rosenheck (2001) share this notion, but instead of routines they view self-reinforcement in relation to organizational culture, i.e. when experiences and challenges are shared, a community of practice is developed on the basis of the patterned social interactions between members that sustain organizational knowledge and facilitate its reproduction. Self-reinforcement, in this sense, is about how organizational life happens, and the existing self-reinforcing mechanisms reflect the identities and behavioral patterns already in existence and forecast what will happen next. Levitt and March (1988) stated that organizational routines not only record history, but shape the future course: each time an organization uses a certain routine, it becomes more proficient at that routine and more likely to repeat it in the future. This has little to do with positive (or negative) feedback, in fact it seems to be the contrary, in this sense self-reinforcement would not represent how a process is accelerating, but how organizational patterns reinforce themselves to remain the same. Nelson and Winter (1982) have the same notion, saying that "within an organization, existing routines serve as templates for producing copies, making their replication possible from day to day, but also over generations of the company´s employee´s. DiMaggio and Powell (1983), however, describe organizational self-reinforcement as a positive feedback process: " organizational inherence patterns are sensitive to the effects of self-reinforcing positive feedback on small, fortuitous events; that is large and successful enough to provide attractive model for imitation". Studying self-reinforcing mechanisms and organizational routines can provide important insights into organizational life. They are at the heart of every organizational path (Sydow et al., 2009) and understanding their internal structures and dynamics can therefore help us explore core organizational phenomena (Pentland and Feldman, 2005).

2. Methods and Results

The rich empirical data are part of an ongoing longitudinal case study of strategizing in a large construction company. A case study design was chosen since our initial aim was to increase understanding of the unfolding of complex phenomena as perceived and narrated on the micro level in the organization (Eisenhardt 1989, Alvesson and Skoldberg, 2000). The data therefore consist of managers' retrospective accounts of change from 1990 to-date complemented by observations of strategy away-days, informal "water-cooler" conversations, and analysis of governing organizational documents. These methods have provided us with a large number of stories, including our own, of organizational life as it is lived.

In accordance with Lynn (1990), who advocates the use of an interpretative approach, our assumption is that organizational members create, embody and enact the realities that they inhabit and, subsequently base their predictions and actions on these. Thus, retrospective interpretations are not only alive in the present moment; they live on into the future through various re-conceptions. Furthermore, individual frames of reference, especially those of managers, are shared and used to create governing realities since managers possess interpretative priority over employees. They can therefore be seen as "practical authors" of the outcomes of the organizational conversations and enactments they have (Shotter and Cunliffe, 2003).

Our findings are aggregated from complementing insights and triangulated data. Iterative analyses between the different data sources led to the proposition underpinning this paper:

> *In construction, a strong common professional or trade identity is a self-reinforcing mechanism through which on-site mindsets and behavior make their way into the boardroom.*

An interview study concerned with how the managers in the organization perceive organizational change over time resulted in a number of interesting findings. For example, the managers' versions of the change trajectory from 1990 to-date depicted a reactive, discontinuous and short-term chain of events that significantly contrasted with the rational, coherent and long-term version found in official documents (Löwstedt et al 2011). Another interesting phenomenon was a strong tendency to personify strategies and changes, i.e. ascribing these to specific CEOs (Löwstedt et al. 2011). The data suggested that managers´ interpretations bespoke a version of organizational life that evolved through a number of seemingly unconnected, reactive episodes, driven by a few "strong persons". Insights into praxis in the organization as well as an understanding of its culture complemented the findings from the interview study. First of all, the formalized career path in the organization (and in the industry as a whole) where recruits start by working the mud on construction sites to then successively progress up the hierarchical ladder. Managers at all levels are very seldom recruited outside of construction spheres, but instead fostered in the building projects during several years before they can acquire legitimacy for promotion. This climbing of the promotion ladder was corroborated during the interview study; the majority of the participating managers had actually “lived” the organizational change they described and they had started their careers on the lower steps of the ladder. They had become strategic managers, because they earned legitimacy in accordance with the established norms of the industry (being construction workers for a significant number of years). These norms can be seen as embedded in the construction industry´s wisdom (Melander, 2008)

Furthermore, field observations revealed that there exists a strong collective sense of pride related to construction craftsmanship. The conversation in the beginning of this paper is a typical illustration of this. Another illustrative example is a comment made by one of the few non-construction recruits working in a central strategic support team.

> *“I have so many times been told that to get anywhere [in the organization], I need to go out and work on the building sites”*

This quote epitomizes an important underpinning of the *identity effect* referred to in the title of the paper.

Even though the majority of the managers participating in this study had been promoted to the rank of strategists, they kept identifying themselves with the original craftsmanship “construction worker”. They furthermore ascribed specific traits to “being a construction worker”, e.g., construction workers [we] are “problem solvers”. And a sense of pride, “we are construction workers”. They also legitimized their current strategy position through the original craftsmanship (the importance of knowing the craftsmanship; knowing how to “construct”).

3. Discussion

We argue that there is a sense of collective identity that permeates members of the organization regardless of role, position, and function. Based on our finding we suggest that “being a construction worker” is an identity, inherent in the cultural capital, that is embedded as a composite part linking the self and the organizational culture (Hermans, 2001). The proposition underpinning this paper suggests that this enactment, this *identity effect*, is at the heart of an organizational self-reinforcing mechanism in which the “construction worker” identity is reinforced across organizational levels. Sydow et al. (2009) develop a framework of different types of self-reinforcing mechanisms at the level of single organizations and organizational sub-units. One of them is *Adaptive Expectation Effects*, which is based around the notion that individual preferences are expected to vary in response to the expectation of other. The dynamic of this self-reinforcing mechanism is driven by a self-fulfilling prophecy, in which organizational members are willing to adopt practices because they expect others to do the same. This tendency is continuously reinforced by the seeking and signaling of “becoming” and “belonging” (Tsoukas and Chia, 2002); individuals who do not subscribe to the mainstream practice may risk losing legitimacy and be stigmatized as outsiders (Sydow et al. 2009: 700). The interactions and interdependency between the self and the organizational culture argued for here could in part be seen as an adaptive expectation effect. The becoming “self” responds to the implicit and explicit expectations of the “culture” and thereby is both reinforced and reinforces the cultural capital, that in turn keeps signaling expectations to the becoming self.

Findings from the case study, indicate, that a collective identity may be reinforced in other ways as well, which warrants future research.

Building projects have often been ascribed specific traits, such as that each building project is unique and that initial plans in building projects seldom corresponds with actual outcomes. These specific traits would call for specific traits of the construction worker challenged by them. A construction worker must be able to adapt to the circumstances surrounding each unique building project and they must be able to adapt to sudden changes in plan. In short, a construction worker needs to be a (and the managers in this study have stated this already) “problem solver”. Construction sites are furthermore still dominated by male workers and much indicates that a “macho culture” prevails. Without digging further into that conception, we have been presented many examples of how you need to know construction yourself in order to get construction workers attention; in order for the “guys [sic] to listen to you”, i.e., you are being legitimized by the construction worker identity.

To conclude, we argue that a “construction worker” identity spans across organizational levels. A simplified yet suggestive analogy could be that they seem to do strategy, as they construct their buildings. Findings from the interview study show that strategic managers perceive organizational change to happen reactively and discontinuously over time, i.e., they solve problems as they arise (Löwstedt et al. 2010b). They furthermore make sense of organizational life via a number of strong leaders, in which personal authority in its own right seems to legitimize organizational change (Löwstedt et al. 2010a).

These traits suggest that the collective identity of “ being a construction worker” is not only reinforced by the adaptive expectation effects between the cultural capital and the self, but also by a community of practice (Rosenheck, 2001, Whittington, 2006), embedded in the specific traits of the building projects, where the strategic managers were once nurtured. Feldman and Pentland (2003) have argued for a revised ontology of organizational routines. They criticize that much of current research portrays the mechanism at the heart of a routine as an object: a static, unchanging, yet regulating object. Feldman and Pentland (2003) advocate instead an ontology in which the mechanism is understood as the collective of constant human activities. These fundamental differences can be related to whether an organization is considered to consist of things or processes, of being or becoming (Tsoukas and Chia, 2002).

We therefore argue for the collective identity of construction workers as a constant “becoming” (Tsoukas and Chia, 2002). The construction worker identity is being reinforced at the interface of self and organizational culture, but also by a community of practice that relates to industry-specific circumstances and the industrial wisdom (Melander, 2008). However, this might hinder important forms of hybridization (Hermans, 2001; Pieterse, 1995), as it is the “becoming to remain the same”.

The *identity effects* proposed in this paper is a self-reinforcing mechanism that spans across operational and strategic levels, albeit the associative behaviors may not always be desirable in accordance. The identity fostered and the practices encouraged in the building projects (e.g. to be able to solve problems when they occur) may inhibit long-term development on a strategic level (e.g. where problems need to be solved before they even occur). The ideal operational identity is somewhat contradictory to the ideal strategic identity, but the *identity effect* is merges the two in a way that may result in a problematic organizational path.

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Ordering Identities: exploring the emergence and consequences of researcher identity

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Abstract

Researchers in the field of construction management have often focussed on developing objectified knowledge to help improve working practices and performance in the industry. Less attention is paid to articulate the researcher's position and how this shapes the way knowledge about the industry is produced and used. However, with growing interest in the co-production of knowledge and the use of more participatory research methods in the field, there is an urgent need for injecting more researcher reflexivity in the analysis and authoring of research. This article is therefore concerned with the significance of the researcher's identity on how new knowledge in the field is claimed. Specifically, the article is based on an ongoing ethnographic study of how airport operators make decisions about developing infrastructure to meet the sustainable development agenda. Data collected to date include field notes from over 750 hours of participant observations, analysis of more than 200 documents, numerous formal interviews and informal conversations with staff at an international airport. A number of 'stories' of critical events have also been co-produced with participants to demonstrate how the airport is trying to become more 'sustainable'. The critical focus of this article is on how these 'stories' have emerged. Ethnographic research has often been associated with benefits of being embedded in the research context and yielding richer and thicker descriptions of observable phenomena. However, becoming an insider can be immensely challenging. This is especially so in the case of the airport where the context is continually shaped by the multiple identities that occupy its space. Consequently, our identity as researchers kept shifting as we sought to make sense of the research problem, the participants and their perspectives. In doing so, attempts were made to find some order in the identities of research participants at the airport and of our selves. Yet, ordering our identities meant that the 'stories' we re-tell were constantly being altered as we sought to simplify what remains a chaotic context. Thus, the implications of ordering the researcher's identity on the way findings are written up and presented are discussed in this article.

Keywords: ethnography, identity, order, research reflexivity.

1. Introduction

Despite recognition of the importance of social relations in the construction industry, dominance of technocratic and rationalistic methods persists in the field of construction management research (see Chan and Räisänen, 2009). Reviewing the last twelve issues of *Construction Management and Economics*, for instance, it was found that a vast majority of articles were based on positivistic research where perceived problems of and within the industry (and their solutions) tended to follow taken-for-granted categories often identified by researchers (see Seymour and Rooke, 1995). Indeed, of the 78 articles published in the last year, 19 (~24%) were about performance and productivity management, 15 (~19%) were on developing new or better managerial systems and processes, and 24 (~30%) focussed on markets, procurement and cost issues. Furthermore, a clear concentration of the use of quantitative methods is noted in the articles found within this sample, even where social relations are concerned. Two striking examples include the study of diffusion of construction innovation (Larsen, 2011) and knowledge integration activities (Ruan *et al.*, 2012), where researchers attempted to explore inter-personal relationships by employing social network analysis.

However, enumerating social relations through rational means is deeply problematic because knowledge about the ‘social’ transcends the order that is often assumed in positivistic conventions. Thus, when trying to depict the social networks that aid in the diffusion of innovation and knowledge sharing, Larsen (2011) and Ruan *et al.* (2012) assembled a representation of inter-personal relationships by drawing lines, which connect nodes identifying well-established labels such as ‘architect’, ‘structural engineer’, ‘main contractor’, ‘sub-contractor’, and so forth. In doing so, a sense of fixity of roles, or *identities*, is being conveyed to readers. In other words, there is presupposition that one ought to know just what these established, orderly labels of professional identities mean and do. Indeed, Larsen (2011) recognised the limitations of such an approach and concluded that the social network analysis would need to be complemented by a deeper, qualitative understanding of just how these relations play out.

In this article, a critical view is taken of the ordered conceptualisations of social relations and identity in organisations that so often permeate within the field of construction management research. Instead of taking such *order* for granted, a proposal is made to consider the arguably more important *ordering* of identities. In doing so, this article represents a contribution to recent calls to problematise identity in construction management (see Brown and Phua, 2011). Of particular concern here is the emergence of the identity of the researcher and how this shapes the data collection and analytical approach. Researcher reflexivity is not a new problem, but one that frequently escapes the attention of construction management researchers. Thus, even though Brown and Phua (2011) urged researchers to account for the fluidity of identity as “the necessary point of origin for investigations of what makes one construction manager successful in the performance of his or her tasks and another less so (p. 84)”, the focus is still about how we identify identity matters of the observed and the observable, and not of the observer.

Given the growing prominence of academic-practitioner collaborations and research that co-produces actionable knowledge (see Sexton and Lu, 2009), it is therefore essential that the researcher’s identity when researching social relations in construction is reflected upon. Such reflexivity is even more crucial where ethnographic research is concerned. Therefore, in this article, reflections on an ongoing ethnographic study of how airport operators make decisions about investing in technologies that help make the airport more ‘sustainable’ are discussed, so as to illustrate the import and implications of the ordering of identities. The article is organised in three main parts. Firstly, a salient overview of ‘identity’ research in construction management is outlined. Secondly, the ethnographic research approach is explained. Thirdly, excerpts from the field data are discussed to highlight the significance of the ordering of the identities of the researchers and researched.

2. Identity problems in construction management research

Brown and Phua (2011) argued that identity issues are under-explored, yet constitute a fertile area of research in the field of construction management. They explained how ‘identity’ plays out in different ways through the construction procurement process, the practices in industry, and the fields of research and education. Identity, they argue, has “most usually been addressed implicitly or in passing by researchers more interested in other empirical issues and directions (Brown and Phua, 2011: 83)”. Indeed, a review of the construction management literature highlights three forms of ‘identity’ that have featured, however superficially, through identity as a label, identity in practices, and identity in a context.

As a label, the construction industry is often identified in terms of its gender make-up (e.g. ‘male/female’, ‘macho’, ‘masculine/feminine’ etc.) and nature of work (e.g. ‘long hours’, ‘hazardous’, ‘physical and dirty work’ etc.) (see e.g. Loosemore and Waters, 2004; Clarke and Gribling, 2008, and; Styhre, 2011). The problems of the industry – such as lack of equality and diversity, lapses in health and safety, bullying and harassment – are often associated with these identities, conveniently expressed as the ‘culture’ of the industry (e.g. Seymour and Rooke, 1995), even though such labels provide little explanatory and remedial power to the ills of social practices in construction (see e.g. Chan, 2011). Another identity label that often features in the literature is the classification of different groups of employees (e.g. managers versus workers, migrants versus indigenous etc.). So, for example, in a recent study of the Australian construction industry, we read of differences in the ways managers and workers conceive of the issue of cultural diversity (Loosemore *et al.*, 2011). In another, we identify with worker’s perceptions of safety training programmes (Wilkins, 2011).

Where identity manifests in practices, researchers have often accounted for its association with project success and organisational performance (e.g. Phua, 2004), typically in the context of forging interpersonal and inter-organisational collaborations in the construction industry. Thus, research on impression management, identity and positioning are becoming more prominent as researchers and practitioners make sense of new ways of working. For instance, Chan *et al.* (2011) observed how project contracts and documentation help mobilise sense-making, sense-giving and sense-hiding processes when creating a new collaborative identity (see also Maitlis and Lawrence, 2007, and; Gioia *et al.*, 2010). Bresnen (2010) assessed how boundary objects are used to develop a collective sense of identifying with project partnering. Others have explored how individuals negotiate their identities in organisations especially when developing new professional identities (e.g. Gluch, 2009, and; Paton *et al.*, 2010). Räisänen and Stenberg (2011) analysed how individuals performed identity as they asserted their positions on a new strategy to mitigate environmental problems in a construction organisation.

Context is also another crucial dimension where identity is considered. In an industry typified by temporary coalitions of multiple organisations, identity and the way in which individuals position themselves often play a critical role in the delivery of construction projects. Indeed, identity has been discussed in terms of achieving chemistry within (Nicolini, 2002), or the development of emotional affinity and attachment (Dainty *et al.*, 2005) to, projects. Given the temporal nature of the project context, Sense and Fernando (2011) recently argued that it is especially critical to understand how individuals become deeply connected with one's work and the work of others in order to inject passionate commitment to the project objectives, as they discussed the significance of a spiritual identity of projects. Indeed, identity is interactional. Individual identities shape and are shaped by the collective organisational identities. As Brown and Phua (2011) assert, the study of identity demands interpretive approaches that would allow for the subjective construction of "multi-layered, nuanced, unfolding and dynamic relationships between self, work and organization (p. 92)."

Brown and Phua's (2011) invitation to refocus the attention on identity matters in construction is certainly a call for researchers to maintain a critical eye over the categories we deploy and depend on. So, for example, in Loosemore's *et al.* (2011) study of the way workers and managers view cultural diversity, or Wilkin's (2011) articulation on worker's perceptions of safety training, is it that straightforward to distinguish between identity categories of 'managers' and 'workers', especially in given the rhetoric of self-management? Do these distinctions *really* matter? Of course, such differences between various groups of employees can only be arbitrary, for the order of labels is merely a matter of convenience rather than, we would argue, one of necessary consequence. Afterall, in Chan and Cooper's (2010) intention to trace the life histories of construction leaders, it is worth noting that the 'leaders' participating in their study – most were chief executives or senior managers of organisations – have often not identified themselves as 'leaders'.

However, of particular concern in this article is the tacit assumption that identity matters exist out there in industry and society for researchers to consider and clarify. So, when Brown and Phua (2011) propose a series of research agendas, they set a tone of 'them' (i.e. practice) and 'us' (research), as they try to excite construction management researchers to take up the challenge of questioning and representing the self identity and all its manifestations of our research subjects. What about our identity as researcher? How do the ways we see our selves influence the way we interpret and order the identities of those we study? As Talmy (2011) noted, researchers are not mere instruments for collecting and recording facts about the world, but actively engage with the researched in a social practice to draw out a representation of reality. Whilst there is a tendency for contemporary researchers in construction management research to begin to appreciate the lived realities of those we study, researchers must also be mindful not to focus only on the context in which our research subjects inhabit; it is certainly vital that we remain sensitive to the possibilities that our research approaches themselves represent a (re-)enactment of context (see Mann, 2011).

Admittedly, whilst it is appropriate to set identity as the starting point for any investigation of practices in the construction industry, it is the identity of our selves as researchers that ought to come under initial scrutiny before one can even begin to problematise the identity of others. Thus, our concern is less about explicating and bringing to order the identities of our research subjects, but more about how our identity as researchers influence, and concomitantly influenced by, the ordering of the identities of our research subjects (see Harding, 2007). To paraphrase Chia (2002), knowledge about identity is certainly not a "commodified 'product'; a thing that can be 'assembled', 'rearranged', 'packaged', 'transferred' and 'consumed' (p. 865)," but a movement of "ceaselessly becoming (p. 866)." The consequence is, nevertheless, quite significant in that the fluidity of our own identities as researchers could result in the re-telling of some organisational tales, and the censoring of others. It is with this in mind that our article on research reflexivity is framed. In the remaining sections, we reflect on a current ethnographic study of how an airport operator makes decisions on investments in their quest to become a 'sustainable' airport. We first trace the origins of this research project and discuss a number critical moments of our sense-making journey to illustrate the chaos and challenges associated with ordering our identities and the identities of our research subjects.

3. Making a 'sustainable' airport: evolution of a methodological approach

The aviation sector has long been under intense scrutiny for its contribution to harming the environment. According to Graham (2008), the environmental problems are particularly acute for airports since they represent soft targets as a consequence of their visibility to local communities. As a result, airport operators around the world have started to respond to political and societal pressure to take sustainability issues seriously, with many incorporating policy instruments within their organisational strategy. Whereas sustainable development is a widely accepted problem in contemporary society, consensus is far from being reached as to how the aspirations of sustainability can be met in practice (see Chan and Cooper, 2010). Nonetheless, sustainability is often framed in terms of the triple-bottom-line, i.e. trade-offs between economic, environmental and social concerns. It is this trade-off process that appealed to the research funding agency in the UK – the Engineering and Physical Sciences Research Council (EPSRC) – in 2008 as they embarked on a £3m research programme to investigate ways to improve the efficiency of airport operations. Reflecting on the lead author's (hereinafter known as 'I') experience of securing funding for this project:

> "'How can we increase air travel and reduce carbon emissions simultaneously?' This was the fundamental question posed by EPSRC in 2008 as they opened up funding possibilities for researchers involved in a Sandpit event aimed at making aviation more efficient. Inherent within the question is that air travel is a good thing and carbon emissions are bad, and more critically, that there was financial value to do what is good and minimise actions that would lead to bad consequences. And so, around 25 researchers (including myself) battled over five days to prove to EPSRC, the funding body, and relevant stakeholder groups that we held the key to discovering the clues that might be of value to answering the question. The constitution of the stakeholder groups is really interesting. Apart from the funders represented by Research Council staff engaged with the Energy Research Programme, there were also representatives from airports and aircraft engine manufacturers, but no one from environmental activism. Airlines were also excluded in the formulation of research proposals, as the boundaries of aviation covered only the operations

confined within the airport infrastructure. Thus, this is very telling about the underlying intentions that shaped the call for research; that any research funded out of this programme had to demonstrate some form of economic value, whether this is immediate or in the longer-term, implicit or articulated." *[Reflective account of the creation of the research project, prepared in May 2011]*

From this extract, it can be seen that a number of agendas are being ordered. So, whereas the funding programme was framed under the umbrella term of 'sustainability', the focus was mainly on (financial) efficiency, marked by the desire to increase air travel, the presence of those involved in the Energy Programme in the Research Council, and the absence of representation from environmental activism. Our identity as researchers was also being ordered through this sandpit event in numerous ways. Most visibly, we were set up to compete with one another for a slice of funding whilst, at the same time, encouraged to collaborate in a multi-disciplinary fashion. Consequently, I found myself shifting my disciplinary position as I sought to find a fit within a project and with other researchers (or kindred spirits) that stood a fair chance of winning some funding. About half the researchers present at the sandpit were already attuned to the research problems in the aviation industry – they were either researching environmental/engineering issues in aviation or transportation – whereas the other half came from a wide range of fields/disciplines, including construction management, building services engineering, economics and finance etc. I recall becoming interested in conversations about trading-off the triple-bottom-line, and more critically, noted the funder's enthusiasm about the prospects of assembling a research team that comprised researchers with expertise in aviation engineering (Cambridge University), financial investment modelling (University College London), and social science (i.e. me). Indeed, I found myself positioning my expertise within the field of organisational studies and social relations, rather than construction management. Yet, as it will be seen in the next section, I remained deeply passionate about the 'infrastructure' dimension that helped me maintain my identity as a construction management researcher. It is also worth noting that a group of researchers specialising in aviation noise and acoustics did not secure funding from this scheme because the remit of the sandpit was focussed mainly on emissions strongly associated with energy consumption.

On securing funding to undertake the research, a decision was made to recruit a doctoral researcher who had grounding, or was interested in developing research expertise, in the social sciences. Furthermore, ethnographic research was elected in part because access was made available to an international airport through its Environment Department (hereinafter known as MyAirport), and also because of the rising interest in ethnographic research in the field of construction management (see e.g. Gherardi and Nicolini, 2002, and; Rooke and Clark, 2005; see also Van de Ven, 2007). It is worth noting that MyAirport's Environment Department was represented as a stakeholder group at the sandpit. Moreover, for an outsider to the aviation sector, ethnography was considered to be a useful approach of becoming embedded in the new research context. It very quickly transpired that airports are chaotic spaces made up of complex assemblages of people (e.g. passengers), objects (e.g. baggage and aeroplanes) and technology (e.g. baggage handling systems, air traffic control) gets assembled and re-assembled as information codes that render order temporary and management control precarious (Knox *et al.*, 2008). Indeed, airports are symbols of liquid modernity (Bauman, 2007), characterised by movements and flux. At the time of securing research funding, change was certainly endemic in the aviation sector in general, and airports in particular. For example, airports had to contend with a number of critical events that would serve to disrupt the order of things, including economic crises, natural disasters (e.g. volcanic ash clouds) and health epidemics (e.g. SARS and H1N1) (see also Doherty, 2008). Thus, this added immense challenges, but also provided a fertile terrain, to consider the ordering (and disordering) of identities.

And so, the ethnographic study reflected here is centred on unravelling the ways actors at MyAirport trade off between economic, social and environmental concerns in their pursuit of becoming more sustainable. The idea of a 'sustainable airport' too is an identity category, however paradoxical. Nevertheless, the data collection process began in August 2010 by embedding the doctoral researcher within the Environment Department of MyAirport. A desk and landside airport pass was also arranged to enable the doctoral researcher to gain regular physical access to the airport during the project (in the beginning, the researcher visited the airport between three to five days a week). Such intense participation by the researcher is necessary in order to create rapport with the research subjects and to become an acceptable participant observer of the proceedings at MyAirport (see e.g. Dawson, 1997). Data was primarily collected through participant observations, supplemented by documentary analysis and interviews airport employees covering various levels of seniority. A total of 750 hours worth of field work have been undertaken, along with 15 formal interviews and many more informal conversations with a range of employees at MyAirport (~ 80), yielding more than 260 pages of transcribed text to date. In addition, over 150 pages of field notes have been created, and more than 200 documents and reports at MyAirport gathered and analysed. Formal interviews were audio-recorded and fully transcribed; the interviewees were drawn from across various functional departments at MyAirport including Operations, Environment, Engineering and Finance. As the data collection progressed, I became more distanced from the spaces of MyAirport and acted mainly in the capacity of a research supervisor, an outsider to cast a critical eye over the emergent findings (see Whyte, 1948, and; Pettigrew, 1973; cf. Dawson, 1997; see also Gioia *et al.*, 2010). In the next section, a number of excerpts vis-à-vis my commentaries as a relative 'outsider' is presented, with a view to lay open some of the dilemmas encountered in the ordering of identities at MyAirport.

4. Some critical moments of ordering identities

In this section, we present three critical snapshots from our ethnographic inquiry at MyAirport to reveal and reflect on how we established an acceptable identity as researchers in MyAirport (labelling), and the critical challenges relating to our identification of what (practices) and why (context) things are done the way they are at MyAirport.

4.1 Identifying with MyAirport (labelling)

As mentioned in the previous section, our route to access MyAirport for the field observations emanated from the link with the Environment Department. A series of interviews with people (4 August; 26 September, and; 10 November 2010) within the Environment Department was set up to obtain a quick overview of MyAirport's operations. Although I had positioned myself as a social scientist during the sandpit event, I rapidly reverted back to assume the identity of a construction management researcher in the early stages of the research. One of the early 'stories' we gathered from entering the Environment Department was its formation, which stemmed from the expansion plans of

MyAirport in the 1990s. At that time, this airport was mainly concerned with maintaining noise levels to an acceptable level from a regulatory perspective. Environmental activities revolved around noise monitoring and control. In the mid 1990s, MyAirport planned to build a new runway. And so, this story provided a useful anchor for me since I, as a construction management researcher, was familiar (and more comfortable) with the story of the new runway as one intimately connected to construction.

Alvesson (2010) crafted seven images of identity in organisations. He argued for a continuum of organisational identities, and stressed that identity is neither statically fixed on one end of the spectrum nor in constant flux on the other end. Of relevance to my acculturation process of becoming identifiable at MyAirport are the three images proffered by Alvesson (2010), including a surfer (i.e. identity as temporal positions), story-teller (i.e. identity as stabiliser), and strategists (i.e. identity as functional). Thus, I initially performed the identity of a surfer, shifting my disciplinary identity from a construction management researcher to a more generic, non-descript social scientist in order to secure funding for the project. When confronted by the messiness of MyAirport, I rapidly assumed the identity of a strategist to delineate functional relationships of the Environment Department at MyAirport, before settling for an early story that best aligned with my established identity as a construction management researcher.

By contrast, the second author (i.e. the doctoral researcher) assumed what Alvesson (2010) called self-doubter (i.e. identity as underpinned by the insecurity of social relations) and struggler (i.e. identity as a possible achievement or uphill battle). It is worth noting that the doctoral researcher has experience in doing public policy research, and so has little affinity with construction management as a disciplinary base. Consider, for example, the following excerpt of an interview with the Head of Engineering, a civil engineer by professional background with experience in highway engineering (interviewed 19 August 2011), which clearly illustrates how the researcher is attempting to order the identity of the interviewee (additional commentary in **bold**):

Researcher: So, how long have you been in this role as Head of Engineering?

Interviewee: Er… 3 years in the next month.

Researcher: Aw, okay, 3 years.

Interviewee: Yes, I am relative a new boy, yeah.

Researcher: ↑Really? Where were you before?

[**Commentary: researcher is assuming the identity of a struggler, as she is making sense of the concept of 3 years being ‘new’.]**

Interviewee: I was with Cheshire County Council.

Researcher: Okay, so you were formerly in the public sector.

[Commentary: researcher is assuming the identity of a strategist, by going back to her functional identity as public policy researcher.]

Interviewee: Yes, I was at Highways management, erm… potted history, I've been with… I was with Cheshire between 86 and 2003 doing various roles, all highway-related, erm… two years in Liverpool City Council, and back to Cheshire in March 2005. I was their Highways Manager… politician, budget management, people management.

Researcher: Was your main background then, highway?

[Commentary: researcher is assuming the identity of self-doubter, as the uncertainty shows despite the interviewee reaffirming his self identity as a civil engineer specialising in highways infrastructure.]

Interviewee: Yes, highway, yeah, yeah, civil engineering by profession, err… highway has been like my area of expertise all my career until I arrive here.

Researcher: Your passion?

Interviewee: Well, this is my passion now (laughs).

4.2 Identifying what things are done at MyAirport (practices)

One of the principal objectives of the study is to help the research team explain the financial approval procedures at MyAirport. In trying to piece together the process, known as Capital Expenditure (CAPEX) approval procedure, accounts of the process were collected through a series of formal and informal conversations. Because the earliest story from MyAirport was about the development of the new runway and how regulatory compliance played a crucial role in determining practices at MyAirport, we were steered towards focussing on critical regulatory points that governed the way things were done at MyAirport. Furthermore, an earlier conversation with a former member of staff in the Finance Department, reaffirmed the significance of regulations, when he stressed:

> "I mean, as you can see there are different areas down there, e.g. operations, contingency air traffic control tower etc., that's been identified as the key risk for the business… so we have to do that. Runway resurfacing, again, if the runway degrades, we shut as an airport. The Department for Transport (DfT) will shut us down. We lose all our money, so again we have to do that." *[Conversation took place 18 November 2010.]*

So, in a subsequent interview with the Head of Engineering, regulatory compliance maintained a high order of priority in our line of inquiry. Consider this excerpt with the Head of Engineering:

Researcher: Because a lot of your work involves regulatory requirements?

Interviewee: Yeah. A lot of reactive stuff as well, you know. We do too much reactive work. That's why, well, the organisation as a whole is trying to change the balance between reactive work and planned work. Let's say for instance, erm, Andy will tell you, when I was on holiday, John on Terminal 2 was just… we were working on the engine, and it blew, bang! Err… so we had to fix it, it's reactive, it's not

> planned. Shit happens, “Guys, go and sort it.” And the age of infrastructure around the place is such that we are doing an awful lot of work. We should really be making the Capital investment. We are doing Runway One at the moment, major capital improvement scheme, so we are less likely to do a lot of the reactive. Virtually, you can’t… by very definition, you can’t plan reactive work, you know it’s going to happens, so you goanna have to have the resources to react to it, but you don’t know where it’s going to happen or when it’s going to happen…

So whereas we as researchers were concerned with identifying the critical concern of regulatory compliance and how this shapes decisions made about practices done at MyAirport, the interviewee’s response was completely divergent to our intent. Instead, the interviewee provided a very cursory answer to the question on regulatory requirements, before stabilising a tale about reactive work which he identified more with. Thus, in ordering what *really* goes on in MyAirport, it is clear that the order in which we undertook our inquiry also affected the order in which reality unfolds for us. Therefore, it is crucial that interpretive researchers trying to identify organisational practices do not re-present selective voices nor arrange them in an order that does not reflect reality. The chronological order in which we carry out the research is thus vital for reflection.

4.3 Identifying why things are done the way they are (context)

On the point about reactive work at MyAirport, a disagreement seemed to manifest in the accounts of the Finance Manager and the Head of Engineering. So, in the earlier excerpt on reactive work that cannot be foreseen, the Head of Engineering appeared to take the view the infrastructure maintenance was something where the expenditure might not be held at a constant. Yet, the Finance Manager’s view is somewhat contradictory, as he explained the intention of MyAirport’s senior management to consider moving towards creating a 25-year capital budget:

> “We going to be having 25 year capital budget, because… a lot of these things are predicable. Because, there are… we have a large site here with a lot of assets on it. Basically, over time it will degrade, and we need to replace them. And… we have a life cycle; we should be able to forecast when you actually spend the money to replace each of them, right? Say if the high voltage network last 15 years, you can forecast that 15 years… really! Erm, a lot of these is just about maintaining our current infrastructure we got here.”

Thus, it is clear from this account that the Finance Manager perceives maintenance work to be relatively more stable and predictable that the illustrative account offered by the Head of Engineering in the preceding sub-section. Still, the Finance Manager is identifying his key contextual assumptions, such as “life cycle”, “forecast”, and “spend”. It is interesting to note that, at two points in this particular excerpt, that self-doubt creeps in, as he formerly questions the adequacy of the life-cycle models and latterly emphasises the ability to forecast expenditure over 15 years by denoting the emphasis “really!”

Nevertheless, this contradiction does present a dilemma for researchers who are trying to establish an order of organisational priorities. How can we identify which priority remains salient? With whose accounts do we identify with? What about the accounts of those we have yet identified with within MyAirport (see Alvesson, 2002)? Thus, ordering contextual accounts of what goes on within the organisations can, at best, only be tentative. As Harding (2007), drawing inspiration from the Lacanian notion of the social imaginary, suggested, "Any sense of interiority can be nothing but imaginary, an imagined object, one that is a lack, a negative, a void we seek to fill with others' recognition (p. 1763)." In ordering our participants' accounts of what goes on in MyAirport and their identification of contextual reasons and priorities, a critical challenge is for researchers to recognise that our research subjects could potentially engage in the process of telling their stories to reflect the object of our desires.

5. Concluding remarks

In this article, we have sought to reject the dominance of technocratic approaches to solving problems in the construction industry and adhere to contemporary calls to refocus the attention on identity matters in construction management research. Our concern, and thus our contribution, is to inject a greater degree of researcher reflexivity not only in terms of how we view the identities of the subjects we study but also of our self-identity as researchers. The reflection of our study of decision-making in MyAirport has revealed potential challenges to the way we order identities through the labels we attach to our subjects and to our selves, as well as the identification of practices and contexts. Order seems to be misguided, and that all we can ever achieve is the state of ordering identities. Indeed, Foucault in *The Order of Things* surmised,

> "what representation provides in a confused and simultaneous form is analysed and thereby rendered suitable to the linear unwinding of language. In effect, description is to the object one looks at what the proposition is to the representation it expresses: its arrangement in a series, elements succeeding elements. But it will be remembered that language in its empirical form implied a theory of the proposition […] conditional upon its being linked together by the patent or secret function of the verb *to be* (1970: 136; original *emphasis*)."

Indeed, as Antonacopoulou and Tsoukas (2002) observed, the science of understanding social relations can only advance because of its inherent incompleteness and revisability. Perhaps, like Chia's (2002) idea of organisations ceaselessly moving, becoming and stabilising, the only order in identity matters is the continual ordering of our selves.

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A Post Construction Evaluation to Study the Impact of Contractors' Attributes on Construction Project Success

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Abstract

The success of construction projects is a fundamental issue for most governments, users and communities. In the literature that deals with construction project success and causes of time and cost overruns in the construction industry, there is some literature that highlights the role of contractors in project success. While most studies rank contractors' success attributes from tendering, prequalification, and a long term historical perception perspective, this research aims to study the impact of contractors' attributes on project success from a post construction evaluation perspective to identify what went right and what went wrong. In an attempt to understand and investigate this impact, a questionnaire survey is used to establish construction professionals' perception of critical success factors (CSFs) of contractors that greatly impact on the success of construction projects. Factor analysis reveals nine underlying clusters namely- (i) safety and quality; (ii) past performance; (iii) environment; (iv) management and technical aspects; (v) resources; (vi) presence; (vii) experience; (viii) past projects; and (ix) finance. Logistic regression techniques were used to develop models that predict the probability of project success. Factors such as turnover history, quality policy, adequacy of labour resources, adequacy of plant resources, waste disposal, size of past projects completed, and company image are the most significant factors affecting projects success. Assuming that project success is repeatable; these findings provide a clear understanding of contractors' performance and could potentially enhance existing knowledge of construction project success.

Keywords: construction project success, project performance, contractor selection.

1. Introduction

According to Ye et al. (2009), the construction industry is one of the most significant industrial contributors to the European economy in terms of gross product and employment. As a result, the success of a construction project is a fundamental issue for most governments, users and communities.

In modern construction projects there are significant challenges for both clients and contractors to deliver the project successfully due to increasing complexity in design and the involvement of a multitude of stakeholders (Doloi, 2009). In addition to the above stated complexity of construction projects, defining project success itself is a complex issue (Toor and Ogunlana, 2010; Lame et al. 2008; Wang and Huang, 2006). Chan and Chan (2004) reported that the concept of project success is developed to set criteria and standards to aid project participants to complete projects with the most desirable outcomes. However, this concept remains somewhat of an enigma as there is no agreement on what should be the critical success criteria on construction projects despite several studies (Ahadzi et al.2008).

The iron triangle (on time, under budget, according to specifications) has been the widely accepted criterion for project success during the last couple of decades. However, Toor and Ogunlana (2010) reported that the same old-fashioned performance criteria can no longer be the sole determinant of project success due to a change in demands of users, evolving environmental regulations, and shifting functions of buildings.

Scholars make a distinction between project management success and project success when attempting to measure success as the two, although related, may be very different (de Wit 1988; Cooke-Davies, 2002; Baccarini, 1999). Pheng and Chuan (2006) pointed out that the successful accomplishment of cost, time, and quality objectives were regarded as project management success. Alternatively, project success deals with the final project objectives. De Wit (1988) concludes that good project management can contribute towards project success but is unlikely to be able to prevent project failure.

Pinto and Covin (1989) pointed out that many of the reasons behind project success can be found in the existence, or lack, of several CSFs. In addition, Belassi and Tukel (1996) asserted that one thing of prime importance in determining project success or failure is the existence of groups of success factors and their interactions.

There are many factors that contribute to project success. Construction projects and their success are highly dependent on contractors (Yaweli et al.2005; Ng et al.2009; Banki et al.2009; Palaneeswaran and Kumaraswamy, 2001). The appointment of the right contractor will not only ensure the overall quality of the project but also offer the opportunity of saving on costs (Yaweli et al.2005). The main contractors start their main duties which impact on the success of a project, when the project reaches the construction or execution stage. During this life cycle the actual work of the project is accomplished. Hence, the aimed of this paper is to investigate the impact of objective and subjective success attributes (criteria) of contractors on construction projects, as they play the main role in project management success which can contribute towards project success.

Over the past few decades, numerous studies have highlighted success criteria and CSFs of contractors. These studies have been expanded by both the industrial and academic worlds. While these criteria and their influencing CSFs have been discussed from tendering, prequalification, and a long term historical perception perspective, the approach in this research is to investigate those criteria from an immediate post construction delivery perspective to identify what went right and what went wrong and record lesson learnt before moving to the next project. An attempt is made to capture the perception of construction project practitioners, in a post construction evaluation, regarding CSFs of contractors that greatly impact on the success of projects, as they play the main role in project success.

Using factor analysis and logistic regression analysis, this research also aims to provide the industry with predictive models that can measure the probability of project success. Assuming that project success is repeatable; the findings from this research seek to provide a clear understanding of contractors' performance and could potentially enhance existing knowledge of construction project success.

2. Methodology

2.1 Research Framework

The approach undertaken for this research comprised two components, a literature review, discussed in the previous section, and an exploratory self-administered survey.

2.2 Survey Questionnaire

The exploratory survey was designed to ask the respondents to rate the impact of contractor CSFs on the success of construction projects. The impact level is measured on a 5-point Likert scale, where 5 denotes strongly agree, 4 agree, 3 neutral, 2 disagree, and 1 strongly disagree. The respondents were required to answer the questions according to actual situations that they had experienced on projects they were working on or had recently completed.

The first part of the survey include some items for collecting background information of the respondents and their projects, such as the respondent's position, experience in the construction industry, type of firm/organisation, procurement type and main project type in the organisation. In the second part of the survey the respondent was asked to rate the impact of CSFs shown in Table 1 on the success of projects. The third part of the survey required participants to comment on the outcome of the completed project. A blank space was provided for the participants so they could suggest their own CSFs that were not been mentioned in the survey. A web based survey using the Survey Monkey website was also developed to increase the return rate.

A pilot study was undertaken to pre-test the survey which was subsequently modified before a final version was produced. The survey targeted client, consultant and contractor organisations involved mostly in infra-structure, residential and commercial projects in the UK. The survey was mailed or hand delivered to 512 participants. One hundred and sixty four completed surveys were returned representing a 32% response rate. The valid dataset was then analysed using the Statistical Package for the Social Sciences (SPSS) version 19.0 for Windows.

3. Data analysis and results

Two statistical tools, factor analysis and logistic regression, were used to analyse data from the survey questionnaire. The main purpose of the factor analysis is to establish which of the variables could be measuring aspects of the same underlying dimensions (Field, 2005). Using SPSS 19.0, the survey opinions of the 35 CSFs were subjected to principal component analysis. Table 2 and Fig.1 present the results.

The results of factor analysis show that the Bartlett test of sphericity is 2283.362 and the associated significance level is 0.000 suggesting that the population correlation matrix is not an identity matrix (Table 2). The Kaiser-Meyer-Olkin measure of sampling adequacy is 0.708 (Table 2), which is considered good (Kaiser, 1974). The average communality of the variables after extraction was above 0.6. Cronbach's alpha of 0.865 suggested the reliability of the research instrument used was also acceptable (Table 2).

The principal component analysis generated nine clusters with eigenvalues greater than 1 explaining 64.6% of the variance (it should be noted that factor (component) 10 was dropped from the analysis as there is no common theme between variables). The factor clustering based on varimax rotation is shown in Table 2. Only factors with loading exceeding 0.50 were selected to evaluate the factor patterns and this reduced the number of factors from 35 to 29. Fig.1 is a scree plot of the total variance associated with each factor. The plot shows a distinct break between the sleep slope of the large factors and the gradual trailing off of the rest.

4. Regression Analysis of Underlying Success Factors

Ordinal logistic regression was selected for this research because the dependent variables were ordinal on a scale from strongly disagrees to strongly agree. Ordinal logistic regression results in more accurate and valid results as it is designed to fit the inherent order or ranking of the dependent variable (Norusis, 2010). The application of logistic regression requires no assumptions about the predictor variables. Hence, the independent variables do not have to be normally distributed, linearly related or of equal variance (Field, 2005).

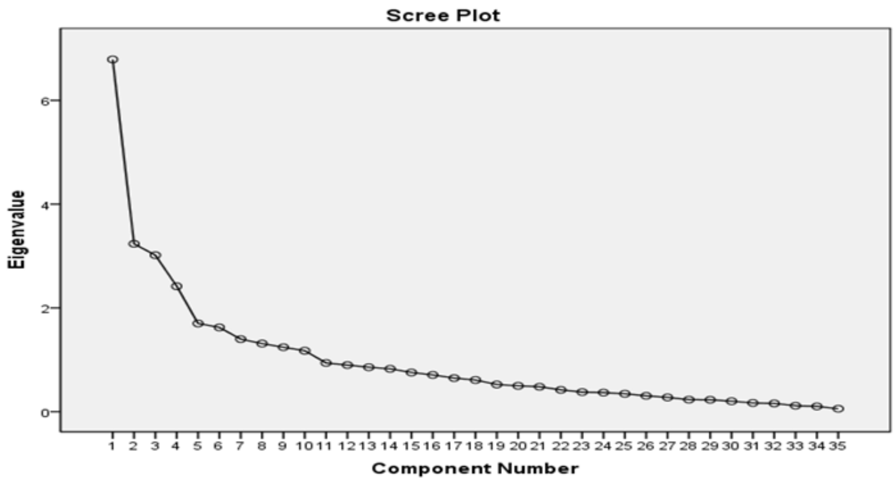

Figure 1: Scree plot for factor analysis

The objective of using logistic regression is to predict the probability that an event will occur. In this study the event is the agreement that the contractors' attributes have an impact on the success of projects. The construction professionals respond to the survey by agreeing or disagreeing with the survey statements. The model then estimates the probability that a contractor with a given set of attributes will impact on a certain project and turn it in to a successful project. The relationship can be expressed in the form of

$$\text{logit}(p) = a + b_1x_1 + b_2x_2 + \ldots + b_ix_i$$

where p is the probability of project success and x_1, x_2 ... x_i are the explanatory variables.

The twenty nine variables that resulted from varimax rotation were entered into the model as independent (covariate) variables to determine which might have predictive ability in relation to project success. The general method of estimating the model parameters is called maximum likelihood (Field, 2005). Log likelihood (LL) represents the probability that the observed values of dependents may be predicted from the observed values of the independents.

Similar in intent to R-Square in a linear regression model, the Pseudo R-Square attempts to quantify the proportion of explained variation in the logistic regression model. In logistic regression analysis, there are two types of R-Square. The first one is Cox and Snell R-Square which cannot reach the maximum value of 1 and the second one is Nagelkerke R-Square which can reach the maximum value of 1. Nagelkerke R-Square is the most widely reported when interpreting logistic regression model (Field, 2005). A deviance statistics test is preferred for assessing model goodness of fit over classification tables.

5. Models Development

Factor analysis reveals nine underlying clusters. However, there is no direct relationship that can be shown by simply applying factor analysis. Hence, logistic regression analysis was conducted to estimate the probability of project success and assess the impact of contractors' attributes on project success.

Using the entire dataset, four logistic regression models were built in SPSS 19.0 to estimate the probability of project success based on the 29 independent variables listed in Table 2. Four dependent variables were used to develop logistic models namely: (1) The probability that a project has been completed on schedule, (2) The probability that a project has been completed within budget, (3) The probability that a project achieved the necessary quality, (4) The probability that the contractors' attributes have an impact on the success of a project. These four measures have been rated by respondents in the third part of the survey that asks respondents to comment on the outcome of a completed project. The analysis was based on the 'enter' method which is the default method of conducting logistic regression in SPSS 19.0 for Windows. The models' summary statistics in Table 3 shows that all models, except quality where the level of significance for the model fit is > 0.05, perform adequately and permit the rejection of the null hypotheses that the independent variables are not related to the dependent variable.

6. Discussion of Regression Results

From the results of logistic regression (Table 3), it was found that the success of a project is significantly associated with seven of the advocated variables. The findings indicate that contractors with adequate labour resources have a great impact on project success. *The* a*dequacy of labour resources* variable was a statistically significant predictor of project success in the scheduling, budget, and contractors' impact models. This is consistent with Belout and Gauvrean (2004), Nguen et al. (2004), Hubbard (1990), and Todryk (1990) who asserted that people are responsible for creating, managing, operating and utilising projects and play a decisive role regarding the success or failure of a project.

The results also show that contractors with adequate plant resources are an important and statistically significant factor affecting project success. The scheduling model reveals that the *adequacy of plant resources* factor is a statistically significant predictor of project success. This result is in accordance with Wong et al. (2003) as they found that on-site productivity can be affected by the availability and suitability of a plant needed for construction activities.

Logistic regression tests also revealed that examining *(company) image* and *turnover history* of a contractor appears to impact on the success of a project. These two variables turned out to be statistically significant in the scheduling model. The model shows a positive relationship between those two predictors and timely project delivery. The result of this finding is similar to findings reported in previous literature such as Holt et al. (1994) who pointed out that insolvency is more likely to occur in the construction industry than in others and confidence from an established trading history needs to be relied upon as a measure of future performance. Isik et al. (2011) and Holt et al. (1994) also reported that financial resources show a company's credibility and reputation and turnover history mirrors company trading with an increase in turnover representing growth.

Although the findings indicate that the overall test of quality model is not statistically valid, the *size of past projects completed* predictor appears to be statistically significant. This finding is consistent with Holt et al. (1994) who asserted that contractors who have the requisite experience from a similar project tend to have a greater impact on project success.

The results show that *quality policy* and *waste disposal* are significant predictors of project success in the contractors' impact model. These findings are in line with previous studies by Attalla et al. (2003) and Chan and Chan (2004) which conclude that quality is a specific issue that needs to be prioritised for a 21st century construction site. The results also indicate that contractors who meet environmental obligations and implement waste disposal programmes during construction tend to have a greater impact on project success.

7. Conclusions

There is considerable debate in project management research practice about what determines project success. While the topic has been discussed for a long period of time, an agreement has not been reached. In addition, when it comes to a definition of project success, there is no single list that is totally comprehensive. However, the concept of CSFs presents a smarter way to identify certain factors which when present or absent in a project are likely to make the project successful.

Construction projects and their success are highly related to contractors. They start their main duties and impact project management success that can contribute towards project success, when the project reaches the construction or execution stage where the actual work of the project is accomplished. In addition, identifying what went right and what went wrong in a post construction evaluation before moving to the next project, proved to be a valuable exercise in construction projects.

This paper reports the statistical results of a survey aimed at collecting perceptions of construction practitioners, in post construction evaluation, about the CSFs of contractors that greatly impact on the success of a project. Based on the available literature, 35 CSFs were selected for this study. By employing a factor analysis approach, the 35 critical factors identified in this study are further categorised into nine underlying clusters namely: *(i) safety and quality; (ii) past performance; (iii) environment; (iv) management and technical aspects; (v) resources; (vi) presence; (vii) experience; (viii) past projects; and (ix) finance.*

*F*our logistic regression models were built to examine the impact of contractor attributes on project success and identify the significant association between the success criteria and the nine underlying clusters. From the results of logistic regression, it was found that the success of a project is significantly associated with seven of the advocated variables. They were: *turnover history, quality policy, adequacy of labour resources, adequacy of plant resources, waste disposal, size of past* *project completed, and company image.* The goodness of fit of the models was confirmed by the -2LL, pseudo R-squared, deviance and parallel lines tests, suggesting that the models are statically robust.

The findings showed that new and emerging criteria such as safety and environment are becoming measures of success in addition to the classic iron triangle's view of time, cost and quality.

Assuming that project success is repeatable; these findings provide a clear understanding of contractors' performance and could potentially enhance existing knowledge of construction project success.

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Table 1: Success attributes and critical success factors

Number	*Success Attributes*	*Critical Success Factors (CSFs)*
1	*Financial Attributes*	*Turnover history* *Credit history* *Bonding capacity* *Cash flow forecast*
2	*Management Attributes*	*Staff qualification* *Management capability* *Site organisation* *Documentation*
3	*Technical Attributes*	*Contractor's IT knowledge* *Knowledge of particular construction method* *Work programming* *Experience of technical personnel*
4	*Past Experience Attributes*	*Type of past project completed* *Size of past project completed* *Length of time in business* *Experience in the region*
5	*Past Performance Attributes*	*Failure to have completed a Contract* *Contract time overruns* *Contract cost overruns* *Past record of conflict and disputes*
6	*Organisation Attributes*	*Size of the company* *Company image* *Age in business* *Litigation tendency*
7	*Environmental Attributes*	*Waste disposal during construction* *Environmental plan during construction* *Materials and substances used in the project*
8	*Health and Safety Attributes*	*Health and safety records* *Occupational safety and health administration rates (OSHAIR)* *Experience Modification Rating (EMR)*
9	*Quality Attributes*	*Quality control* *Quality policy* *Quality assurance*
10	*Resource Attributes*	*Adequacy of labour resources* *Adequacy of plant resources*

Table 2: Factor analysis and total variance explained

Description of clusters	*Factor loading*	*Variance explained*
Cluster 1**: **Health, Safety and Quality		*19.4*
Quality policy	*0.755*	
Quality assurance	0.733	
Occupational safety and health administration rate (OSHAIR)	0.680	
Health and safety records	0.627	
Quality control	0.625	
Experience Modification Rating (EMR)	0.589	
Cluster 2**: **Past Performance		9.2
Contract cost overruns	0.896	
Contract time overruns	0.916	
Past record of conflict and disputes	0.848	
Failure to have completed a contract	0.793	
Cluster 3: Environment		8.6
Waste disposal during construction	0.870	
Environmental plan during construction	0.879	
Materials and substances used in the project	0.828	
Cluster 4: Management and Technical Aspects		6.9
Management capability	0.605	
Site organisation	0.586	
Knowledge of particular construction method	0.755	
Work programming	0.727	
Cluster 5: Resources		4.8
Adequacy of labour resources	0.908	
Adequacy of plant resources	0.811	
Cluster 6: Presence		4.6
Size of the company	0.743	
Company image	0.645	
Age in business	0.659	
Cluster 7: Experience		3.9
Experience in the region	0.677	
Length of time in business	0.774	
Cluster 8: Past projects		3.7
Type of past project completed	0.853	
Size of past project completed	0.897	
Cluster 9: Finance		3.5
Turnover history	0.650	
Credit history	0.857	
Cash flow forecast	0.694	
Cumulative variance explained= 64.6%		

Note: Kaiser–Meyer–Olkin measure of sampling adequacy=0.708
Bartlett test of sphericity=approx. chi square 2283.362; *Df 595*; and Sig=−0.000.
Cronbach's Alpha= 0.865
Extraction Method: Principal Component.

Model	Predictor	B	S.E.	Wald	Sig	Model fit information			Goodness-of-fit:		Pseudo R-square	
						-2 Log Likelihood	Chi-square	Sig.	Deviance chi-square	Sig.	Cox and Snell	Nagelkerke
Scheduling	*Adequacy of labour resources*	-1.284	.494	6.756	.009*	267.451	50.885	.007*	267.451	1.000♀	.312	.345
	Adequacy of plant resources	1.016	.429	5.615	.018*							
	Company images	.612	.279	4.804	.028*							
	Turnover history	1.081	.318	11.533	.001*							
Budget	*Adequacy of labour resources*	-1.224	.491	6.203	.013*	267.131	44.398	.034*	267.131	1.000♀	.279	.310
Quality	*Size of past project completed*	-.893	.413	4.687	.030*	203.269	29.868	.421	203.269	1.000♀	.198	.241
Contractors' Impact	*Quality policy*	1.103	.451	5.978	.014*	220.469	54.587	.003*	220.469	1.000♀	.333	.382
	Waste disposal	1.208	.519	5.414	.020*							
	Adequacy of labour resources	1.229	.531	5.345	.021*							

* Significant *at $p < 0.05$*
♀ *Sig> 0.05, so the model fits well*
S.E.: *Standard Error*
df (degree of freedom)=1

Table 3: Logistic regression results

The architect's changing role in the design of buildings in the U.S.A

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Abstract

The increasing complexity of building systems has challenged the traditional design roles and responsibilities in the construction industry. Rapid improvements in building technology and materials have surpassed the technical abilities of many architectural and engineering firms resulting in an increased design fragmentation and specialization. To overcome this knowledge gap, architects and engineers have traditionally relied on the expertise of contractors and manufactures. However, this reliance was considered only for the means and method of construction. Evidence indicates that this dependence is not limited only to the means and methods but there is an increasing number of building performance engineering tasks that are being designed by entities associated with construction. This design input, generated through shop drawings and mockups, has not been timely recognized as a design activity by the American Institute of Architects (AIA). The position of AIA is discussed by analyzing the content of its standard form of contractual agreements for design and construction services namely B101 and A201 for the last seventy years. Contrary to what is suggested in these documents, the industry practice shows that the design is not a finite activity but a continuum throughout the construction process. The increasing use of design delegation to parties traditionally not involved in the architectural profession poses the need for reconsidering and redefining the central role and services of architectural designer in the making of buildings.

Keywords: *Design delegation, Contractors, Shop drawings, Design Services, AIA contracts*

1. Introduction

Traditionally design and construction activities have been treated as independent activities. Design was perceived as an activity that was completed at the submission of contract documents for bidding. It was assumed to be little interaction between the designer and the contractor after the submission of construction documents. Construction, on the other hand, was seen as performed by specialists, namely the contractor and subcontractors, who were experts in the means and methods of constructability. This view has been largely supported by construction management books as well as in the agreements for professional services. Based on these documents, the architect maintains a presence during construction by administering the contract between the owner and the contractor.

The increased complexity of building systems and the abundance of new technologies available, especially after WWII, have shifted the design knowledge largely to manufacturers and specialty contractors. It is therefore convenient for a design professional to rely on the expertise of manufacturers and contractors for designing/engineering building systems based on quality and performance specifications.

In turn, this design activity is provided by the contractor, subcontractors or manufacturers during construction in the form of shop drawings. These documents are not properly categorized as performance engineering design nor are they recognized as part of contractual documents. In contractual agreements they are presented simply as the demonstration of understanding the design intents and as the reflection of means and methods to be employed during construction activities. Historically they have been interpreted as necessary only to accomplish the work in terms of construction means and methods and not of design.

This paper presents a review of the standard contracts for design and construction services as they were promulgated by the American Institute of Architects (AIA) in the past 100 years. The analysis of AIA B101 (agreement between owner and architect) and AIA A201 (general conditions of the contract between the owner and contractor) over the years show that the design contribution by contractor, generated through shop drawings and mockups, has not been timely recognized as a design activity.

Differently to what has been suggested in these documents, the industry practice has shows that the design is not a finite activity with the completion of working drawings, but a continuum throughout the construction process. The increasing use of design delegation to parties traditionally not involved in the design profession poses the need for reconsidering and redefining the central role and services of architectural designer in the making of buildings. Only recently, did the AIA include provisions to recognize the design input from the parties that execute construction activities.

2. Technological Complexity

Contemporary buildings still serve the same principles of purpose as their centuries old predecessors. However, they have evolved considerably by becoming synonymous with complex machines. Building systems and their constituents have grown increasingly complex by providing a secure and an environmentally controlled space.

Ford (1990) explained that modern building design is characterized as a passage from conceptually “monolithic” to a “layered” system of construction. The first type denotes a technological framework where the same building system meets multiple functional and aesthetic requirements, and it is implemented through a series of construction activities that involve a limited number of trades. The latter, by contrast, indicates a system that results from the assembly of different materials and autonomously produced components. It is a reflection of both the increasing specialization of design knowledge and the fragmentation of design and construction activities.

Natural materials, such as stone and wood, were the main building elements used in the early-nineteenth century construction. The application of these materials required skilled labor and considerable on-site activities. This method of construction started to change during the Industrial Revolution where new manmade materials were introduced. The use of structural steel and reinforced concrete caused a fundamental shift in the structural design process by transforming external walls from load bearing to non-bearing walls thus allowing for increased flexibility in the arrangement of internal space (Purdy 1896). These new technologies along with the use of elevators facilitated the vertical expansion of buildings. The use of electricity for lighting and other purposes, together with the developments of mechanical air ventilation and cooling/heating between the two great wars, added new means for achieving environmental comfort. Moreover, building codes and regulations unceasingly mandated improvements in regards to safety, pollution control, and increased security. More recently, energy conservation concerns, emphasis in the use and preservation of natural resources, and computer and communications applications have added additional technological content in buildings. Solutions of complex aesthetic and structural problems by means of modeling software have escalated dramatically in the last twenty years resulting in very complex architectural forms such as those of Frank Gehry and Zaha Hadid.

The increasing technological complexity of buildings is reflected in the shifting cost distribution of their parts over the years. The average historical cost data reported by R.S. Means (RSMeans Company 1983, 2011) for 1983 to 2011 show the growing relative economic importance of the mechanical, electrical and plumbing systems (MEP), particularly in regard to structural systems. In 1983 the percentage cost of the MEP systems in hospitals and college laboratories represented 27% and 36% of the total building cost. In 2011 these percentages had reached 45% and 50% respectively. A similar trend can be seen in less technology intensive buildings such as hotels, where MEP accounted for 37% in 1983 and for 46% in 2011.

These data indicate that some types of buildings are characterized more by machinery than bricks and mortar. The architect is called to coordinate and integrate a growing amount of specialized design data into his architectural representation quite often changing the form to accommodate the function.

Hence, the increasing demand for specialized technology and the necessity for a faster adaptation of new technologies woven together with the abundance of new materials and building products have expanded the traditional scope of services performed by the architect. The knowledge gap is filled by design consultants and specialty trade contractors. Actually, there is a specialist for every aspect of the building, from the foundation to skin selection (Liebing 2008). The increasing dependence on consultants, manufacturers, and specialty trade contractors has added complexity to the relationships among the project participants.

3. The increase of off-site production

Given the increasing technological complexity of buildings and the need for satisfying cost and time schedule constraints, construction activities have been relying on the use of off-site manufactured parts. Labor intensive activities requiring the assembly of discrete components have been replaced with pre-manufactured assemblies that are delivered and installed according to schedule. Reducing on-site labor activities, lowering construction costs and time, increasing quality control coupled with environmental concerns and waste reduction have accelerated the use of prefabricated and preassembled building parts.

The use of steel in buildings marked the start of off-site manufacturing to some specific requirements and delivered ready for assembly in the late XIX century. Advances in building technology along with improved manufacturing capabilities increased the use of prefabricated elements. In addition to steel, a sizeable part of elevators, HVAC, MEP, curtain wall systems, not to mention fixtures and infill elements, currently are manufactured off-site. The design expertise for these systems does not rest with the architect. Instead it is concentrated on the manufacturers and installers (and their consultants) of such components. Consequently, the use of prefabricated components has amplified the practice of shop drawings generated by manufactures and subcontractors to satisfy specific performance requirements.

Traditionally, shop drawings have been developed on the basis of the architect’s working drawings to illustrate the way building components are fabricated, assembled together and installed onsite. The reason behind this practice was simply because manufacturers needed to make the drawing suitable for their own shop production methods. Conventionally these documents have been associated only with the means and methods of construction. However, there is evidence, that an increasing number of building performance engineering tasks is being designed through the use of shop drawings alone.

Hallowell and Toole (2009) in analyzing twenty $5-$45M design-bid-built construction projects found that 35 performance engineering tasks were required by project specifications to be performed by entities associated with construction. Performance engineering tasks impact the overall functionality of a building and, if not completed efficiently, have negative consequences on the safety and health of its occupants. The collapse of L’Ambiance Plaza that killed 16 workers in 1989 was attributed to deficiencies in performance engineering tasks (Heger 1990). Pietroforte (1995), showed that the design of a thin veneer curtail wall is a long engineering design process whose functional performance is eventually verified with a physical mockup testing.

For some very complex buildings the use of performance specifications is of course a necessity in order to take advantage of the design knowledge of specialty trade contractors and manufacturers. This approach, developed in the UK after the second war, was introduced in the US during early 1960’s to smooth the transition between working drawing and shop drawings. Performance based specifications indicate that there is much design being executed after the architect’s issuance of final design documents.

The above mentioned technological complexity and use of prefabricated components raises several considerations regarding the design role of the architect in the building delivery process. Technological complexity suggests that over the years the design has evolved from a single source into the coordination of many specialist contributions and that its meaning has been enriched with new types of functional dimensions. Differently, off site production suggests the use of performance specifications and shop drawing, that is, the execution of additional design engineering activities by entities not necessarily linked with the design professional. This last observation suggests that design-activities span across the conventional design and construction phases of a building project. The following notes illustrate how the US architectural profession institution has addressed the above raised issues over the years.

4. AIA Contractual Agreements

During the building process, the architect offers both design and construction contract administration services to the owner. The scope and the extent of these services are described in two well recognized contractual documents published by the American Institute of Architects (AIA), namely The Standard Form of Agreement between the Owner and Architect AIA-B101 and the General Conditions of the Contract for Construction AIA-A201. The first contract between owner and contractor was published in 1888, followed by the first edition of the General Conditions in 1911. The first agreement between architect and owner was released in 1917 (Dundin 1988). Since then, these documents have been revised and coordinated regularly to integrate evolving construction practices and react to court cases. With its 125 years history and with more than one hundred forms and construction contracts, the AIA plays a dominant role in the construction industry of the United States. AIA documents are widely recognized as construction industry standards and in themselves can be seen as mounting to “private legislation” (Sweet 1991).

The consideration of the above mentioned types of contracts is broken down according to two periods: before 1997 and after 1997. That year, in fact, marked a major shift in the documents, especially in the A-201. New provisions dealt openly with the issues of delegation of design responsibilities to the contractor, via performance and design specifications.

4.1 Standard form of agreement between the owner and architect 1917 – 1987

As stated before, the first owner-architect agreement was published in 1917 (AIA 1917a, b) and consisted of two versions: Percentage based and fee-plus-cost forms of payments. In the first version, the services provided by the architect are described in a single article, Article 1, with professional services consisting of "...the necessary conferences, the preparation of preliminary studies, working drawings, specifications, large scale and full size detail drawings; the drafting of forms of proposals and contracts; the issuance of certificates of payment; the keeping of accounts, the general administration of the business and supervision of the work. This version offers a generic description of the architect services. Little information is given about the role of design consultants. The review of shop drawings are embedded in the fee-plus-cost version under Article 3, the Architect's Costs that includes:

"The sums paid for drafting, including verification of shop drawings, for specification writing and for supervision of the work."

"The sums paid to structural, mechanical, electrical, sanitary or other engineers."

However, no further details are given to define neither the scope of services provided by these consultants nor the scope of architect's services during construction, other than to "endeavor to guard the Owner against defects and deficiencies in the work of contractors, but he does not guarantee the performance of their contracts".

Design continued to be described in general terms until the 1951 edition, when the following is added to the architect's services to include work not usually performed by the architect:

"…large scale and full size drawings, for architectural, structural, plumbing, heating, electrical, and other mechanical work;…" (AIA 1951a).

This addition implies the reliance and the role of design consultants during the design phase. Nonetheless, these services listed under the umbrella of architect's services did not clearly convey to the owner that the design was provided also by entities outside of the architect's office.

The 1958 edition, AIA B-311 presents a departure from all prior editions. Under this document, the provided design services flow through three distinct phases listed as the schematic design, design development, and construction documentation. In addition, the role of the architect during construction is clearly stated as a separate activity. Thus, for the first time, there is a clear separation of duties of the architect. His role as a designer is considered concluded with the completion of construction documentation phase. It is only under the construction phase that the architect "reviews the shop drawings for compliance with design" and "provides general administration of the contract", a term used to replace the troublesome "supervision" (AIA 1951b, I.4). A possible explanation for the observed changes may be attributed to the challenges the architectural profession was experiencing in the late fifties. New types of project delivery, then known as "package service", were introduced with a combination of design and construction services (Bannister 1954). Producers were delivering building parts of larger sizes and the trend toward prefabrication was affecting architectural practice.

With the addition of the bidding and negotiation phase in the 1967 edition, AIA B131, the description of the basic services of the architect remained the same. The drawings and specifications developed during the construction document phase, described in details the necessary requirements for construction of the entire project. (AIA 1967b, 1.1.6) Architects provided a descriptive set of instructions or requirements for the final size and character of the buildings. This practice continued for some twenty years. The 1987 edition recognizes for the first time the input of architect's consultants as part of the architect's basic services. Until that year, by concentrating solely on the owner-architect relationship, the agreement gives the impression that the architect was the sole designer who provided a complete and constructible package prior to bidding and negotiation phase. Design input via shop drawings is considered only during the construction phase of the project, but only for "the limited purpose of checking for conformance with information given and the design concept expressed in the contract documents" (AIA 1987a, 2.6.12).

The various editions of the "handbook of architectural practice" offer additional information about the architect's role during the examined period, although they are not contractual documents. First introduced in 1920, the handbook (AIA 1920) outlines the architect services offered during the design phase in more detail. The following quotations resemble the duties prescribed in the architectural agreements almost 40 years later,

a. *Making preliminary studies of the problem, the results being expressed in a report or more frequently in the form of a sketch or sketches for a design;*

b. *The preparation of working drawings, specifications and detail drawings;*

c. *Drafting forms of proposals and contracts, issuing certificates of payment, keeping accounts and carrying on the business administration incident to the conduct of the work.*

d. *The supervision of the work as it is executed.*

The input and dependence on consultants was duly noted in the architectural practice since the turn of twentieth century. Increasing technological complex systems, such as heating and ventilation, electricity, and plumbing, required for successful application to depend on "professional specialists who could give the entire time in studying of these systems" (AIA 1920, p. 16). The architect, therefore, progressively became a coordinator of specialized design services, although this issue is not addressed in the owner/architect agreements. According to the 1953 edition (AIA 1953), shop drawings are defined as a "necessary step between architects' working drawings and actual construction". Regardless of how careful the working drawings and the amount of details placed on them, the architect could not make them acceptable to the trades and to all the shops in which the work was to be made.

4.2 A201 – General Conditions of the Contract for Construction 1915 - 1987

The best-known and widely used owner-contractor document is A201, General Conditions of the Contract for Construction that is coordinated with B101. Originating in 1888 and currently in its sixteenth edition (A201-2007), it is used for projects where the design and construction are contracted separately. It is also known as the design-bid-build contract delivery. It reflects the entire and integrated agreement between the owner, architect and the general contractor. It also describes the duties, responsibilities, and relationship among these parties.

The document often refers to the required work of the contractor. In the second edition (AIA 1915) of the contract the term “work” was limited to supplied labor and material and remained unchanged until 1967. In 1915, the contractor was required to furnish all the samples for approval as per Article 8 (AIA 1915). In 1958, the contractor, in addition to labor and materials, was required to provide satisfactory evidence on the quality of the materials as per Article 9 (AIA 1958b). In 1967 the term work included “all the labor necessary to produce the construction required by the Construction Documents”, as per subparagraph 1.1.3 (AIA 1967a). In the context of the first half of the century the contractor is presented as a “producer” and all the information generated via shop drawings is considered as part of production. These drawings and other calculations are integrated in terms of construction means and methods only and not as engineering design tasks. The 1987 edition included a provision that touched upon the issue of design delegation. The scope of contractor’s work, in addition to providing materials, labor and equipment necessary to fulfill its obligations, was updated to include “services” as required by contract documents. Subparagraph 1.2.3 of the 1987 edition (AIA 1987b) required the contractor to produce the results “intended” through the contract documents defined as the drawings, specifications, and addenda. This provision, therefore, required the contractor to participate in a design entity by analyzing and interpreting the design professional’s intentions. The issue of design delegation is briefly addressed in subparagraph 3.12.11 that states:

“When professional certification of performance criteria of materials, systems or equipment is required by the Contract Documents, the Architect shall be entitled to rely on the accuracy and completeness of such certifications” (AIA 1987b).

Although design delegation has taken place for many years, prior to 1987 there was little AIA contractual guidance as to delegation of design to the contractor. Parties were left to draft their own design delegations or rely on informal agreements (Potter 1998). The court’s decision on the structural failure of the Kansas City Hyatt Regency hotel in 1981 prompted the AIA to clarify on the issue of design delegation.

4.3 B101 – Standard form of agreement between the owner and architect 1997 - 2007

The B141-1997 edition of the owner-architect agreement represented a “fundamental departure” from the earlier editions (AIA 1997c). To accommodate increasing specialization within the architectural profession, B141 was divided into two parts separately addressing agreement terms and scope of architectural services. Past practice of grouping the architect' services into phases applied to a linear model of delivery. The intent of this separation was to create a more flexible platform for the rendering of architectural services that were no longer grouped into phases. Instead, the services were grouped into six primary categories that included administration, planning and evaluation, design, construction procurement, contract administration and facility operation. The extent of services in general approximated those outlined in the 1987 edition with one exception regarding the information included in construction documents.

Differently from the previous editions, design engineering services could be delegated to the contractor through performance and design specifications by outlining the quality level of materials and systems. Subparagraph 2.4.4.1, among others, reads:

"The Construction Documents shall include Drawings and Specifications that establish in detail the quality level of materials and systems required for the Project."

Subparagraph 2.6.4.3, pertaining to submittals that is, the information provided by the contractor after contract execution, indicates:

"If professional design services or certifications by a design professional related to systems, materials, or equipment, are specifically required of the Contractor by the Contract Documents, the Architect shall specify appropriate performance and design criteria that such services must satisfy. Shop drawings and other submittals related to the Work designed or certified by the design professional retained by the Contractor shall bear such professional's written approval when submitted to the Architect. The Architect shall be entitled to rely upon the adequacy and accuracy and completeness of the services certifications or approvals performed by such design professionals".

There is clearly a shift on the design responsibilities placed upon entities associated with construction. Until 1997, according the AIA documents, contractors' design responsibilities were related only to means and methods. After 1997 their contribution became an integral part of the overall engineering and performance of a building.

The flagship of owner-architect agreements B141 was discontinued in 2007. The B141-1997 had "created undue complexity for the architect providing traditional architectural services" and for the architects who did not provide design and construction services (AIA 1997c). Therefore, B101 returned to the services provided by the architect during the five phases, as they existed prior to the 1997 edition.

B101-2007 acknowledges that, during construction phase, in order to construct the work, the contractor will provide additional information such as shop drawings and other submittals (AIA 2007a, 3.4.1). This statement leads into the assumption that shop drawings related to the engineering performance tasks are still part of the means and methods of construction. Differently, the work as defined in A201, in addition to materials and equipment, includes services in which the contractor must satisfy performance and design criteria set forth by the architect.

The history of AIA standard contractual agreements indicates that the design as performed by the architect ends with the issuing of contract documents. The design input by contractor and manufacturer is not appropriately acknowledged until 1997.

The use of performance specifications in contractual agreements and the expected additional information by contractors in terms of shop drawings, indicate that that these documents do not only describe the means and methods of construction as in the past, but they are in fact a complement that details the design intent of the architect.

4.4 A201 – General Conditions of the Contract for Construction 1997 - 2007

The issue of design delegation plays the center stage of the A201, 1997 edition. Under this agreement, the contractor is expected to provide design engineering services based on performance specifications outlined by the architect or the owner (AIA 2007b, 3.12.11). But, because the contractor is not a licensed professional, the A201 requires that such services be provided by a properly licensed professional who must certify all the shop drawings, calculations, and all other required submittals. Once the shop drawings are developed based on the required performance specifications, these drawings can no longer be regarded as just documenting the means and methods of construction only. Since they provide engineering calculations, these shop drawings are in essence engineering design tasks.

The issue of design delegation resonated through construction industry generating considerable opposition. The substantial risk shift to contractors prompted the Association of General Contractors of America (AGC) to reluctantly endorse this document. The 2007 edition of the contract was not endorsed by AGC for the first time in fifty years (Alitz 2008).

Shop drawings are used to materialize the design intent as given via performance specifications notwithstanding, they are not considered part of contract documents (AIA 2007b, 3.12.4). "…the purpose of the submittals is to illustrate how the contractor intends to implement the architect's design. Because the owner may not have the opportunity to agree with changes incorporated into shop drawings product date or samples, the submittals from the contractor to the architect cannot represent the mutual agreement of the parties to the same degree as the contract documents." (AIA 2007c, 3.12.4)

The statement that the design can be delegated to and generated by the contractor during the construction phase breaks the linearity of project delivery as described in both B101 and A201 documents. As the design intent of working drawings is refined and sometimes changed after their submittals, contracts documents do not envision a collaborative design undertaking with specialty trade contractors, manufacturers and their professional consultants. Their inputs are considered only after the completion of the construction contract documents by the architect.

5. Conclusions:

The increasing technological complexity of building systems followed an by an escalation of pre-fabricated assemblies after the WWII has altered the design process from that presented in general literature or in the AIA contractual documents namely A201 and B101. Design is considered as a finite activity completed at the end of the design phase. On the other hand, construction has been understood as a subsequent activity that strictly implements the instructions given in the drawings and specifications. Contrary to this assumption, design continues well onto construction phase of the project. This part of design process has been considered as pertaining to the means and methods of construction only, and not as an activity contributing to the overall performance of the building. Shop drawings not only refine the architect's intent but they also have a more profound role in the design and functionality of the building. Only recently has the architectural profession duly recognized and accepted these design inputs.

The technological progress has weakened the ability of the architect to maintain her historical role as the only depositary of design knowledge. Unable to fully cope with the growing number of innovations, the architect has resolved by shifting certain specialized design responsibilities to consultants and specialty trade contractors by means of performance specifications. The shifting of design liabilities has altered the role that manufacturers and specialty trade contractors play on the fulfillment of the design. The design input by entities traditionally associated with construction was finally recognized by the architectural profession. The architect is no longer the only designer but rather the coordinator and integrator of different design contributions. The contractor and manufacturer, on the other hand, have become extensively involved in design activities related to the engineering performance on the building.

The increase use of design delegation to parties traditionally not involved in the architectural profession poses the need for reconsidering and redefining the central role and services of architectural designer in the creation of the buildings. New professional agreements should clearly recognize that modern building design/engineering is not an individual activity but the coordination and integration process of multidisciplinary inputs that span across the traditionally separated phases of designing and constructing a building. The shifting roles of architect and contractors also should be recognized in the educational programs by developing coordination and integration capabilities in architectural schools and applied building design/engineering capabilities in construction oriented schools.

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Architects' Perceptions of Political Tactics in Construction Project Organizations

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Abstract

Political tactics in organizations have been the subject of numerous studies. The emergent conclusion from these studies is that political tactics in organizations are an inevitable part of any human-based activity and can have functional or dysfunctional consequences. The construction process is one such human-based activity. Managing political tactics in a construction project organization is a key challenge facing social actors (i.e., architects, clients, main contractors, and subcontractors). Managing political tactics and reducing their dysfunctional consequences start with identifying and understanding the political tactics that are used by social actors. The research presented in this paper builds on this premise and empirically explores the use of political tactics by social actors in construction project organizations. A survey that was administered to 101 architects revealed that political tactics are common in construction project organizations. Furthermore, the research findings suggested that each social actor has its own unique set of likely/unlikely political tactics and that the main contractors, rather than clients and subcontractors, engage in the extensive use of political tactics in construction project organizations.

Keywords: Political tactics, perception, construction project organizations, architects

1. Introduction

The concept of political behavior in organizations has been an important research area addressed in the literature for more than three decades. It has been addressed from a wide range of research perspectives (e.g., Harvey and Mills 1970; Zaleznik 1970; Pettigrew 1973; Allen et al. 1979; Pfeffer 1981; Farrell and Peterson 1982; Mintzberg 1983; Drory and Romm 1990; Ferris et al. 1989; Vigoda 2003; Doldor 2007) with each having its own assumptions and propositions for studying political behavior in organizations. Yet, they all have led to the conclusion that organizations are becoming more political entities in today's business environment. Thus, managing political behavior has become an important skill for the social actors of organizations due to functional and dysfunctional consequences of various political behaviors. A succinct review of the literature that addresses organizational studies revealed that the concept of political behavior has been studied predominantly at the intra-organizational level (i.e., within the boundaries of the organizations) (e.g., Pettigrew, 1973; Allen et al., 1979; Pfeffer, 1981; Farrell and Peterson, 1982; Mintzberg, 1983; Ferris et al., 1989; Vigoda, 2003; Doldor, 2007). The review also revealed that political behavior in construction projects (i.e., political behavior across the boundaries of organizations) is a relatively neglected research area in the construction management literature despite the fact that the well-known characteristics of construction project organizations (e.g., one-off in time, place and people, fragmentation, fierce competition, and uncertainty) encourage the use of political behavior. This neglected research area was the focus of the work discussed in this paper, which empirically explored the concept of political behavior in the context of construction project organizations.

2. Political Behavior

The term 'political behavior' must be defined as the starting point for understanding political behavior in organizations, which is a multi-dimensional concept. Defining such a concept is a major challenge, because there are numerous definitions of political behavior in the literature and because the phenomenon of 'political behavior' is described by several other terms, including organizational politics, work politics, and political process. Several succinct observations and views of political behavior in organizations have emerged (e.g., Harvey and Mills, 1970; Zaleznik, 1970; Pettigrew, 1973; Allen et al., 1979; Pfeffer, 1981; Farrell and Peterson, 1982; Mintzberg, 1983; Drory and Romm, 1990; Ferris et al., 1989; Vigoda, 2003; Doldor, 2007), including (1) there is no consensus on what political behavior means; (2) it is futile to search for a common definition for political behavior; (3) researchers who hold the rationalists' view argue that political behaviors are inappropriate, unethical, unacceptable, and undesirable; (4) social actors can use political behavior maximize the achievement of their own self-interest(s); (5) it can have dysfunctional consequences, such as conflict, employee turnover, stress, job anxiety, job dissatisfaction, lower productivity, cost overruns, low quality, unmet objectives, hostility, and reduced morale; (6) researchers who accept the sociological view argue that political behaviors are an inevitable part of organizational life; (7) social actors can use it to achieve organizational objectives or common interest(s); and (8) it can produce positive consequences, such as achieving project goals, enhancing creativity, and creating constructive relationships.

Political behaviors in organizations have been studied at three different levels: (1) *tactical level*, (2) *strategic level*, and (3) *style level* (Overton and Frolick, 1996). The most commonly studied level of political behavior is the tactical level followed by the strategic level, with the style level receiving less attention than the other two levels. While research on the tactical level of political behavior has progressed to a mature state of development, the strategic and style levels are still in the early stage of development. The tactical level has received overwhelming interest from researchers mainly due its immediate operational effect on organizational and project performance (Pinto, 2000). Furthermore, the tactical level of political behavior constitutes the building block for studying and understanding the strategic and style levels of political behaviors.

2.1 Political Tactics

Tactics refer to specific techniques for promoting desired results, which distinguishes them from strategies that pertain to specific maneuvers rather than general plans. As a subset of political behaviors, *political tactics* are used by social actors to *influence* other social actors to achieve their own self-interest(s) or common/mutual interests. The term *influence* herein can be defined as the intentional attempt to affect another to feel, think, or behave in a desired fashion (Elron and Vigoda-Gadot, 2006). Several classification schemes have been proposed to study political tactics in organizations. The pioneering research study of Allen et al. (1979) constituted an important milestone for research studies of political tactics in organizations. The primary of focus of their study was to identify the political tactics used by social actors to "get what [they] need." They proposed that political tactics used by social actors be categorized into eight groups: (1) attacking or blaming others, (2) using information as a tool, (3) creating a favorable image, (4) developing a base of support, (5) ingratiation, (6) forming power coalitions with allies, (7) associating with influential people, and (8) creating obligations. Appelbaum and Hughes (1998) proposed a conceptual framework for studying political tactics. They argued that political tactics used by the social actors in organizations include: (1) forming coalitions, (2) impression management, (3) information management, (4) promote the opposition, (5) pursue line responsibility, (6) ingratiation, and (7) devious political tactics. The first six political tactics they identified are similar to those proposed by Allen et al. (1979), but the seventh one represents a number of devious political tactics, such as the 'take no prisoners tactic,' the 'divide and conquer tactic,' and the 'exclude the opposition' tactic. The conceptual framework proposed in their study has not been tested empirically. Zanzi and O'Neil (2001) argued that there are two distinct categories of political tactics: (1) sanctioned political tactics and (2) non-sanctioned political tactics. Sanctioned political tactics are the political tactics that social actors consider acceptable because they are part of the organization's norms, i.e., use of expertise, super-ordinate goals, image building, networking, persuasion, and coalition building (Zanzi and O'Neil, 2001). On the contrary, non-sanctioned political tactics (i.e., intimidation and innuendoes, using surrogates, blaming or attacking, manipulation, organizational placement, co-optation, and control of information) are considered by social actors to be unacceptable, undesirable, and performed secretly (Zanzi and O'Neil, 2001). Sussman et al. (2002) reviewed the classification scheme proposed by Allen et al. (1979) and argued that one of the original eight political tactics overlapped significantly with another political tactic proposed in their classification scheme. They modified Allen et al.'s (1979) classification scheme by reducing the number of political tactics used by social actors from eight to seven. These seven political tactics proposed by Sussman et al. (2002) included: (1) attacking or blaming others, (2) using information as a political tool, (3) creating and maintaining a favorable image, (4) developing a base of support, (5) ingratiation, (6) developing allies and forming power coalitions, and (7) creating obligations and reciprocity. Sussman et al. (2002) reported that the first and second most frequently used political tactics are ingratiation and developing power allies/forming power coalitions, respectively. The least commonly used political tactic is using information as a tool. The following section briefly presents Sussman et al.'s (2002) classification scheme for studying political tactics.

Attacking or Blaming Others. This behavior is often associated with blaming others for a problem or failure. It may also include trying to make a rival look bad by minimizing her or his accomplishments.

Using Information as a Political Tool. This behavior may include withholding important information when doing so might further an employee's political interests. This type of behavior can also include information overload.

Creating and Maintaining a Favorable Image. This behavior includes drawing attention to one's successes and the successes of others, creating the appearance of being a team player in the organization, and developing a reputation of possessing qualities considered important to the organization.

Developing a Base of Support. Examples of this behavior include getting prior support for a decision before a meeting is called and getting others to contribute to an idea to secure their commitment.

Ingratiation/Praising Others. This behavior includes praising others and establishing good rapport for self-serving purposes.

Associating with influential people. This behavior involves developing good relationships with influential people in organization and in social situations.

Developing Power Coalitions/Strong Allies. This behavior includes developing networks of co-workers, colleagues, and /or friends within and outside the organization for purposes of supporting or advocating a specific course of action.

Creating Obligations and Reciprocity. This behavior includes performing favors to create obligations from others.

3. Construction Project Organization as a Political Arena

A construction project organization is a socio-technical system that requires simultaneous *collaboration* and *competition* among social actors. Such a requirement, coupled with the well-known characteristics of construction projects (i.e., one-off in time, place, and people, demand-driven, method of price determination, temporary multi organizations, fragmentation, and fierce competition), promotes various kinds of political tactics and turns the construction project organizations into *political arenas*. Each construction project is a unique solution to a specific design problem reflecting the needs of a client. Construction project organizations develop abstract solutions to design problems and then transform the solutions into physical reality. This process is a knowledge-intensive process that requires the generation and processing of enormous volumes of information and knowledge. For the most part, the knowledge requirements for a construction project are dynamic processes that change from one project to another. The changes are necessary because each project requires its own design and generates new production problems regarding the integration and coordination of the outputs of the specialized groups that conduct interdependent tasks. The demand for construction projects commonly takes the form of pre-demand purchase (i.e., before the construction project has begun). The predominant method of price determination used in the architectural engineering and construction industry (AEC) is competitive bidding, which fuels fierce competition and even leads to the development of "perfect competition." Social actors who operate in an industry that fosters fierce competition are almost "price takers" and have low profit margins. The client of Architectural Engineering and Construction (AEC) industry commonly initiates the construction project, which is then conducted by a temporary alliance of autonomous and heterogeneous organizations called Temporary Multi-Organizations (TMOs) (Cherns and Bryant, 1984). Each independent specialist member of a TMO (i.e., architects, engineers, construction material vendors, general contractors, and subcontractors) conducts interdependent and specialized tasks for achieving the objectives of the project. The process of meeting the needs and requirements of the client is composed of a series of interdependent subprocesses (i.e., different phases of a project). Autonomous and heterogeneous social actors are involved in each subprocess. The presence of a series of interdependent subprocesses (e.g., project lifecycles - conception, design, and construction) leads to vertical fragmentation, whereas the involvement of autonomous and heterogeneous social actors to conduct interdependent tasks in each subprocess causes horizontal fragmentation (i.e., different specialists involved in a project). Both vertical fragmentation and horizontal fragmentation commonly act as barriers to collaboration and facilitate conflict between/among autonomous and heterogeneous social actors of the TMO. Social actors that are involved in TMOs face two sets of conflicting objectives, i.e., (1) the objectives of the TMO, which are to achieve the objectives/interests of the construction project and (2) the objectives/interests of their permanent organizations (Morris and Hough, 1987). The implications of these conflicting objectives/interests become evident in the adversarial relationships that plague construction project organizations. The characteristics of construction project organizations discussed above (i.e., one-off in time, place, and people and unique, fragmentation, fierce competition, and uncertainty) and social actors' characteristics (i.e., personal values, self-interest, egos, needs, perceptions, goals, methods, and objectives) jointly create a fertile ground for the emergence of political tactics in construction project organizations. The following section presents the research methodology used to explore political tactics in construction project organizations.

4. Research Methodology

4.1 Data Collection

In this research, a questionnaire was used to conduct a survey designed to explore the use of political tactics in construction project organizations. There were two reasons for using this approach, i.e., (1) previous research studies (Allen et al., 1979; Sussman et al., 2002) used questionnaires to explore the political tactics used by social actors and (2) research related to the use of political tactics in organizations is in an advanced stage of development. Therefore, exploring the use of political tactics in construction project organizations is theory-testing research rather than theory-building research. It is well documented in the literature that the use of a questionnaire should be the first choice for theory-testing research studies. Reliability in the data collection stage of our research was ensured and improved by following the recommendations and guidelines suggested by previous research studies (e.g., Sussman et al., 2002; Zanzi and O'Neill, 2001).

The questionnaire we used to collect data for exploring the use of political tactics in construction project organizations included open-ended, Likert-type scale and ranking questions, and it consisted of two parts. The first part of the questionnaire solicited information on the demographic profiles of the participants (i.e., age and gender), the years in which the firms were established, and the number of employees. The second part of the questionnaire included a series of questions regarding the use of political tactics in construction project organizations. In this part of the questionnaire, the participants were asked to respond to politically-related messages that were received rather than sent. The rationale for this wording was the fact that the aim of the questionnaire was to solicit sensitive information regarding the use of political tactics, and participants may avoid responding to questions that were perceived as socially undesirable (Sussman et al., 2002). A pilot study was conducted to control readability and clarity of the questionnaire. Twenty-five graduate students in the Engineering Management program at the İzmir Institute of Technology participated in the pilot study. The questionnaire was revised based on the feedback received from the participants. The data collected in pilot study were not used for any further analysis. Subsequently, data were collected on use of political tactics in construction project organizations from a sample group of architects who participated in a seminar entitled "*Consultation Council of Independent Architects*," which was organized by the İzmir branch of Chamber of Turkish Architects. The seminar was intended to (1) discuss the problems that plague the practice of architectural design and (2) inform participants about alternative ways of addressing and overcoming these problems. The architects who attended the seminar were requested to complete the questionnaire. Therefore, the research findings represent only the views of architects on the political tactics that commonly are encountered in construction project organizations.

5. Research Findings and Discussion

Questionnaires were distributed to 180 architects who participated in the seminar. From that number, 22 people did not return the questionnaire, 57 questionnaire forms were discarded because some sections were not completed or instructions were not followed. Thus, the results reported in this paper are based on the responses of 101 architects (N = 101). Table 2 presents the age profile of the architects who completed the survey, the years their firms were established, and the number of full-time employees at each firm. It is clear from Table 1 that the architectural design firms/offices with which participants were associated were small in size and had been in business for several years.

Table 1: Age Profile of Architects, the years their firms were established, and the number of full-time employees at each firmof their

Architects (N=101)			Age of Architectural Design Firms			Size of Architectural Design Firms	
Age	Percentage		Age	Percentage		Number of Employees	Percentage
21-30	17%		1970-1980	3%		0	17%
31-40	41%		1981-1990	19%		1	24%
41-50	34%		1991-2000	41%		2	23%
51-60	7%		2001-2008	37%		3	19%
Over 60	1%					Over 4	17%

5.1 Political Tactics in Construction Project Organizations

Table 2 presents means and standard deviations of political tactics used by social actors in construction project organizations. The tactic of creating a favorable image was ranked first by a general consensus among the social actors (i.e., standard deviation = 1.48). The tactic of creating obligations/reciprocity was ranked fourth, and there was less agreement about this ranking among the participants (i.e., standard deviation = 1.68). It is clear from Table 2 that the most commonly used political tactic in construction project organizations was creating a favorable image. The second and third most frequently used political tactics were ingratiation and attacking or blaming others, respectively.

Table 2. Use of Political Tactics

Political Tactic	Mean*	Standard Deviation
Creating a favorable image	4.21	1.48
Ingratiation	3.91	1.73
Attacking or blaming others	3.72	1.59
Creating obligations/ reciprocity	3.57	1.68
Using information as a tool	3.37	1.51
Developing a base of support	3.29	1.64
Developing allies/ coalitions	2.96	1.56
*1 = Infrequently - 7 = Frequently		

Table 2 also suggests that the least commonly used political tactic in construction project organizations is developing allies/power coalitions. The research findings on the use of political tactics in Turkish construction project organizations differ from previous research studies on the use of political tactics (Allen et al., 1979; Sussman et al., 2002). Allen et al. (1979) reported that the most commonly used political tactic in U.S. organizations is attacking or blaming others and that the least commonly used political tactic is creating obligations and reciprocity. Furthermore, the research findings of Sussman et al. (2002) revealed that the most frequently used political tactic in the U.S. organizations is ingratiation and the least commonly used political tactic is using information as a political tool. These inconsistent research findings can be explained by a number of factors. First, these two research studies were conducted at different times, with 23 years between them. Environmental factors, such as social, cultural, economic, and legal factors, tend to change with time. It should be noted that environmental factors have changed significantly since both research studies were conducted. Second, the previous research studies (Allen et al., 1979; Sussman et al., 2002) were conducted in the U.S. Yukl et al. (2003) argued that cross-cultural differences could influence the frequency of use of political tactics. The political tactics of the social actors depend mainly on their cultural circumstances, and each social actor reflects her or his cultural values and traditions when interacting with other social actors. If culture is a moderator for the relationship between social actors and their political tactics, it would seem natural and expected that different tactics would emerge in different cultures (Yukl et al., 2003). Third, the unit level of analysis used by previous research studies was political tactics within the boundaries of the organizations. Yet, the research findings reflect the perceived use of political tactics across organizational boundaries (i.e., architectural design office, client and construction firms, including the main contractor and subcontractors). It is entirely possible that the combination of these three factors could have influenced the research findings presented in this paper.

5.2 Use of Political Tactics by Social Actors

Architects' views regarding the use of political tactics in construction project organizations by main contractors, subcontractors, and clients are presented in Table 3. It is clear from Table 3 that the most common political tactics used by the main contractor, subcontractors, and clients are creating a favorable image, ingratiation, and attacking or blaming others, respectively. The most common political tactic used by subcontractors was ingratiation, whereas the most common political tactic used by main contractors was creating a favorable image. Table 4 presents the most likely and the least likely political tactics used by main contractors, subcontractors, and clients.

Table 3. Use of Political Tactics by Social Actors

Political Tactic	*Social Actors*		
	Subcontractor	*Main Contractor*	*Client*
Creating a favorable image	*31*	*<u>54</u>*	*16*
Ingratiation	*<u>52</u>*	*33*	*16*
Attacking or blaming others	*30*	*40*	*<u>31</u>*
Creating obligations/ reciprocity	*35*	*52*	*14*
Using information as a tool	*34*	*52*	*15*
Developing a base of support	*23*	*52*	*26*
Developing allies/ coalitions	*42*	*46*	*13*

Table 4. Likely/Unlikely Political Tactics of Social Actors

Social actors	*Political Tactics*	
	Most likely Political Tactics	*Least likely Political Tactics*
Subcontractor	*Ingratiation*	*Developing a base of support*
	Developing allies/ coalitions	*Attacking or blaming others*
Client	*Attacking or blaming others*	*Developing allies/ coalitions*
	Developing a base of support	*Creating obligations/ reciprocity*
Main contractor	*Creating a favorable image*	*Ingratiation*
	Creating obligations/ reciprocity	*Attacking or blaming others*

Table 5 presents the frequencies of the usage of political tactics by main contractors, subcontractors, and clients. It summarizes the counts for the 101 participants across the political tactics. The main contractors had the highest frequency (35%) whereas the clients had the lowest frequency (19%) in using political tactics. These findings can be explained by the characteristics of the conventional delivery method, which is the method that is most commonly used by Turkish clients to construct their buildings. The conventional delivery method creates two types of relationships, i.e., (1) contractual relationships and (2) functional relationships. In the delivery method, both the architects and the main contractor have contractual relationships with the client, whereas the architects and the main contractor have only a functional relationship. It is possible that this functional relationship fuels the frequent use of political tactics by the main contractors against the architects and vice versa, because neither of the social actors has power and authority over the other. To the contrary, clients have contractual relationships with the architects, so they can exercise their power and authority to manage relationships with the architects, thereby reducing the need for using political tactics. These findings are consistent with those of previous research studies (Sussman et al., 2002; Falbe and Yukl, 1992) that concluded that power and authority of the social actors are related inversely with their use of political tactics. The research findings also provided empirical support for Allen et al.'s (1979) argument that the choice of political tactics usually depends on the social actor's hierarchical position in the organization.

Table 5. Usage of Political Tactics by Social Actors

Social actors	*Frequency*	*Percentage*
Subcontractor	*247*	*35%*
Client	*131*	*19%*
Main contractor	*329*	*46%*

6. Conclusions

The primary objective of this research was to investigate the political behavior that commonly occurs in construction project organizations. It explored political behavior at the tactical level in construction project organizations from architects' points of view. Therefore, the research findings represent architects' perceptions regarding the use of political tactics by primary social actors of construction projects (i.e., main contractors, subcontractors, and clients). However, since architects are not the only social actors of TMOs, future research studies should explore political tactics from other social actors' points of view. Such a research study could ensure the generalizability of the research findings and produce important insights on how to manage the dysfunctional consequences associated with political tactics in TMOs.

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Study on Organization and Conflict of International Construction Projects: Case Studies of Chinese and Japanese International Contractors in China and the UAE

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Abstract

This paper reports the results of a comparative research project on the organization of international construction projects in China and the United Arab Emirates (UAE). This paper discusses three actual international projects that were carried out in the UAE and China. We compare the differences in the formation of the project team organizations and the conflict within the organizations to present the characteristics of Chinese and Japanese overseas project delivery systems, clarify the features of overseas project team organizations, and identify the strengths and weaknesses of each organization.

This paper is a part of an on-going research project initiated to explore the quality confirmation, procurement, and contracting system of overseas construction projects. The fundamental goal for future research is to explore how an international contractor can work more effectively in overseas construction markets, especially those with complex surroundings. The results of this study might benefit contractors who wish to engage in or have engaged in overseas projects, help them avoid some of the same problems that were pointed out in the research, and provide more rational considerations to improve competitiveness.

Keywords: International Construction Project, Project Organization, UAE, China, Japan

1. Introduction

Over the past decades, China and the Middle East have developed into two of the most dynamic construction markets in the world, which has created more opportunities for international contractors to enter these construction markets. This is particularly true in the United Arab Emirates (UAE); according to World Bank estimates, 60%-70% of all development investments in Third World countries are ploughed into construction activity. The Engineering News Record has estimated that, in recent years, more than 2000 international construction firms have been competing for work in the UAE. By now, many large-scale or fast-track projects completely depend on these foreign contractors.

After a review of the existing literature, international construction projects were found to be distinct from non-international constructions in that the former involve interactions among individuals, organizations, and agencies from diverse national backgrounds and cultural contexts. Such interactions, even on technologically routine international construction projects, often lead to additional misunderstandings, increased transaction costs, friction between project participants, and coordination and communication difficulties (Orr 2005). Consequently, to succeed in the international marketplace, construction businesses must effectively and efficiently deal with the diverse cultures they encounter. However, the UAE construction industry is more complicated as it involves more complex factors. In addition to the intensified market competition, laws, and regulations, the national culture is a very obvious factor. Furthermore, consulting engineers come from different counties, mainly in the West such as the UK, the USA, France, and so on, and the workforce comes from India, Pakistan, Bangladesh, Sri Lanka, the Philippines, and, increasingly, China. Such cultural differences are an important issue in all aspects of project management, from the tending and negotiation phase to construction operations (Jim 1986).

According to researchers who identified risks in the UAE construction market, excluding external risks such as “inflation and sudden changes in prices” and “shortages in resources supply”, internal risks such as “performance and management of contractors and delays of material supply by suppliers” and “the lack or departure of qualified staff from the contractor side” are significant issues in the UAE construction market (Sameh 2008). Due to the diverse and complex nature of these issues, problems such as cost overruns, schedule delays, and conflicts face foreign contractors; these problems have started growing and become readily apparent in the UAE construction market.

2. Study objectives

As mentioned above, a project is an open system that has interrelationships and interaction with its surrounding environment. Thus, we looked at a construction project as a focal organization consisting of actors with which a project management system has direct links. The cultural factors appear at three levels: (1) as internal forces when it concerns the project personnel and work groups; (2) as external forces when it concerns adaptation to the cultural environment of the host country and interaction with other actors involved in the project; and (3) as an organizational culture when it concerns the relationship with the headquarters and as a product of the construction firm (Hossein 1992).

For this purpose, we focus here on the organization of the project management system. The study aimed for a better understanding of (a) the information of project team organization and how the organization is influenced by the construction environment (b) and an explanation of the unique conflicts that arise in multicultural project team organizations.

3. Methodology

Because this paper is presenting an initial study on this subject, three actual projects were carried out in addition to documental research in general. Four clusters of variables, including the project organization, composition of work force, actors involved in the project, and project performance, were studied in detail.

In addition to a detailed individual study of each project, semi-structured interviews with general contractors and research into general information on each country or area were conducted. These justified the legitimacy of the conclusions reached on the differences in management approaches, principles, and backgrounds between the general contractors from each country and project.

The three projects presented in this paper are as follows.

Table 1: Outline of projects

Project	E	F	G
Location	Shanghai, China	Dubai, UAE	Dubai, UAE
Client (CL)	Private	Private	Government
Consultant/Architect (AR)	Chinese firm	Lebanon/Japanese firms	British/Chinese firms
General contractor (GC)	Japanese A Company	Japanese B Company	Chinese C Company
Construction period	13 months	17 months	12 months
Building purpose	Factory	Apartment building	Warehouse
Contractual arrangement	Design Bid Build	Design-Build	Design-Build

E Project

This case represents a simple construction project of a factory in Shanghai, China. The project was commissioned by a Japanese private investor. The project delivery system was design-bid-build (DBB) contracting. The GC was a major contractor of A Company of Japan. The subcontractors (SCs) were local Chinese companies. All of the workers were Chinese. The project was not complex in terms of building technique, but the GC's construction manager changed twice, and the project overran both cost and time.

F Project

This project involved the construction of a 17-storey apartment building. The project delivery system was design and build (DB) contracting. The client was a large UAE-based multinational corporation. The consultant was an Arab firm. The GC was B Company of Japan. The SCs were domestic companies, and the workers came from India; some of the general contractor's own workforce (WF) came from Thailand. At the intermediate stage, the project had overruns of time and cost.

G Project

A major warehouse project was commissioned by the UAE government. The project was complex, and urgency was an important factor, the project duration was 12 months. The project delivery system was DB contracting. The consulting engineers were from the UK, and the client was Arab. The workforce comprised people of different nationalities: 80% of the workers came from China, and 20% of the workers came from India. A diversified project management team headed by a Chinese project manager was arranged. An example of the managerial issues in this project was the gaps between the Chinese general contractor and British consultant.

4. Project organization analysis

E Project

The project team organization chart of E project is shown in Fig.1. It is a distinctive project organization which has become a popular procurement style used by Japanese contractors in China. In this route, the GC agrees to a lump sum price with the client and is directly responsible for all of the work. This means that the GC carries the liability not only for the work it does directly but also the liability for work performed by the subcontractors and suppliers.

A second feature of the project is the organization of the construction supervisor (CS). According to Chinese law, as a normal project it must be managed by a CS. The CS is hired by the owner and acts as the owner's representative on site and supervises/manages all aspects of a construction project, including the quality, progress, and cost.

The third distinctive feature of the project is the organization of the design process. As shown in Fig. 1, the contractual arrangement is DBB. The client performs detail design work together with the architect before contractors are procured. In this case, however, only the domestic architect had a contract with the client. In truth, most of the main design work was carried out by the Japanese GC's supporting group. As shown in Fig. 1, the Japanese GC had in-house capacity; it provided staff assistance for site organization, reviewed the architectural structural M/E design, provided necessary working drawings, solved technical problems, did initial executive planning and value engineering, confirmed the work quality, etc.

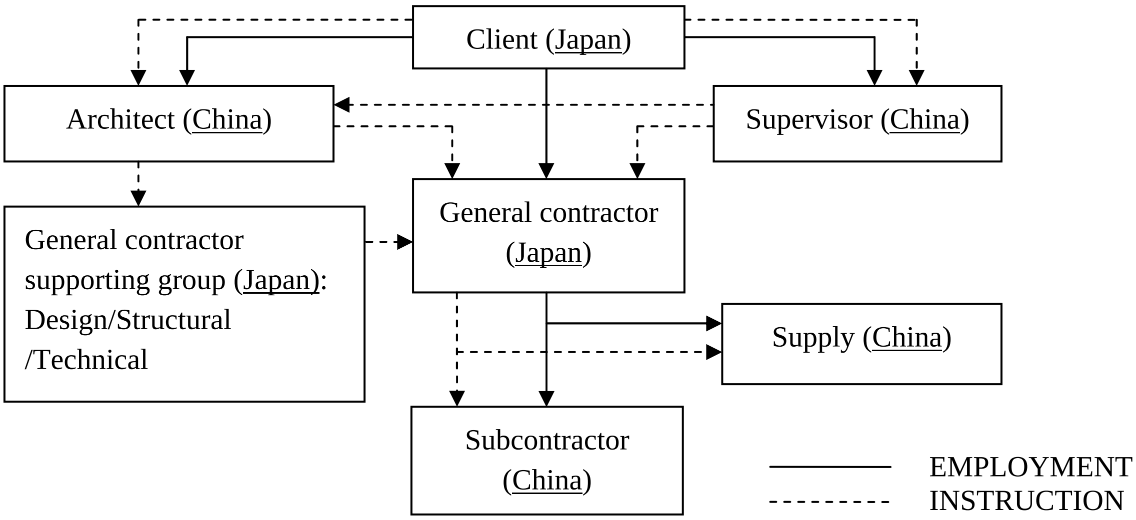

FIG. 1 Project Team Organization of E Project

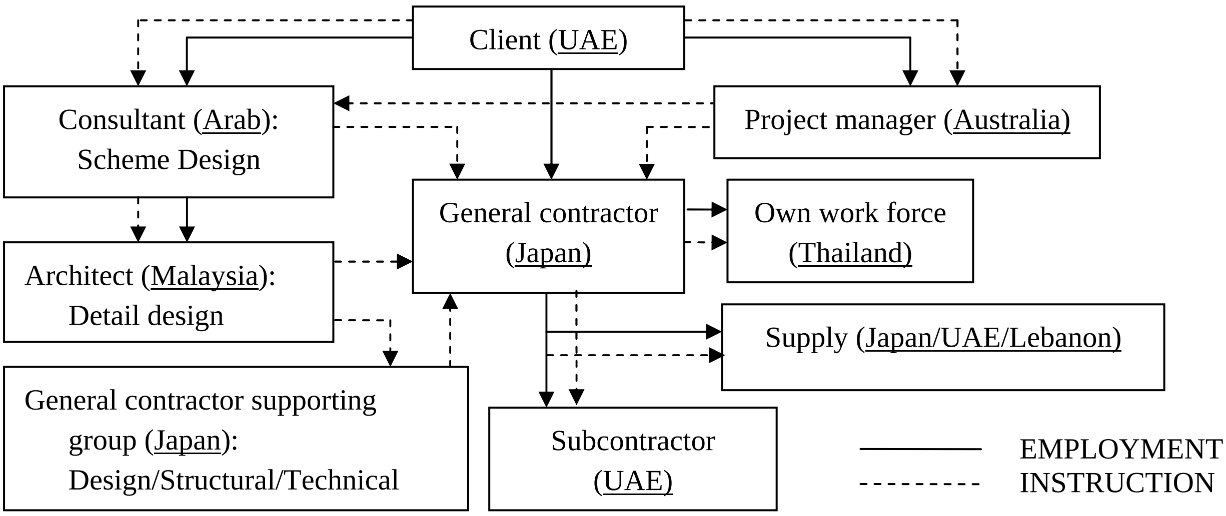

FIG. 2 Project Team Organization of F Project

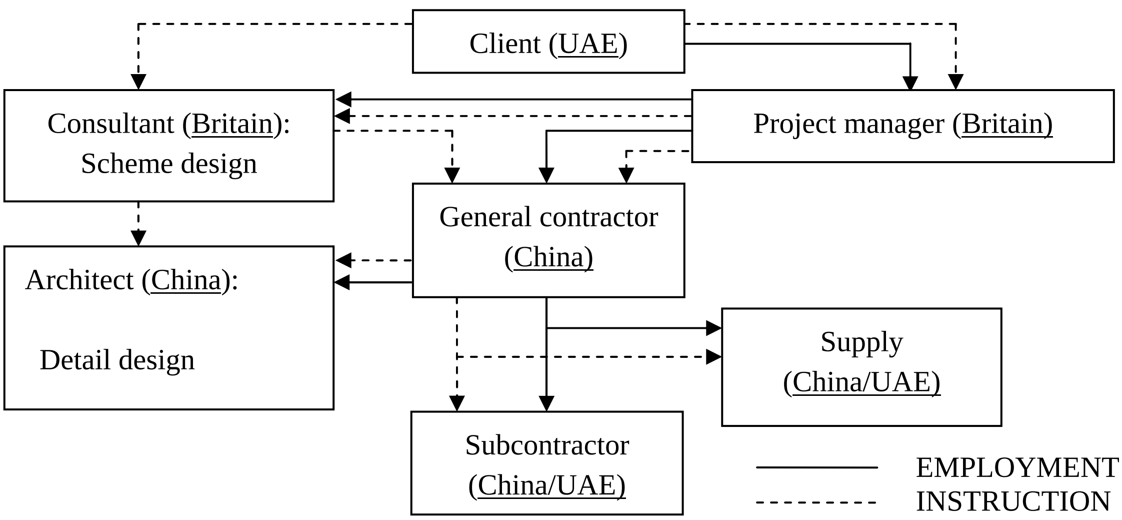

FIG. 3 Project Team Organization of G Project

F Project

The organization of F project is in sharp contrast with the structure of E project, which is shown in Fig. 2. Here, the client hired a project manager (PMr). The PMr was a large Australia-based multinational PM corporation with a contractual relationship based on the FIDIC contract. This contract clearly described the roles and responsibility of the PMr, such as giving instructions, issuing drawings, certifying the work, fairly determining and making decisions on the contractual issues, etc. Compared with the CS of E project, the construction manager had a wider range of rights and bore the full responsibility for the client.

In this case, an Arab architect consultant firm was hired by the client, but was different from that used for E project. The consultant only provided the scheme design; the detail design was subcontracted to another architectural firm from Malaysia. Based on the project brief and sketched drawings, the GC's architect team did the engineering design and specification.

In contrast to E project, there was a workforce (about 30 workers) besides the local subcontractor that was hired directly by the GC. They completed part of the project under GC's payroll. Almost all workers were well-disciplined labourers from Thailand who had been working for B Company in other countries. In this case, they acted as work group leaders in charge of general carpentry work, concrete, steelwork, and formwork.

G Project

The project team organization chart of G project is shown in Fig. 3. Here, the client hired a PMr, a British consulting firm. Similar to the PMr of F project, it also acted as the owner's representative and had overall control of the project, including selection of A/E & GC, design evaluation, construction work supervision, payment and financial arrangements, etc. In contrast to the PMr of F project, the construction manager had a contract relationship with the consultant and GC.

In this case a British architectural firm was hired by the PMr and was responsible for providing a scheme design. Detail design work was subcontracted to the GC. A Chinese architectural firm was hired by the GC to do the engineering design and specifications. The architectural firm set up a specific position with the title of resident architect (RA). The RA reported to the architect, was the representative of the architect on site, interpreted drawings and specifications issued by the architect, controlled the work quality, etc., and generally acted as the communication channel to the architect.

The chief architect noted that "In the UAE, fast-track construction is a popular delivery system. Scheme design and detail design are usually done by two consulting firms. In this project, we had to allocate two resident architects (RA) to the site because the detail design was according to the scheme design provided by the British consultant. If they changed the scheme, we changed the detail immediately, and issue these changes to the general contractor for construction feasibility."

Another feature of the project was the subcontractor and the work force. In contrast to the Japanese GC, the Chinese GC contracted with a subcontractor in China and brought the project management team and construction workers from China. In this case, 80% of the subcontractors were the Chinese company and 90% of the structural work was carried out by its own workers from China who were in its direct employ. There were various reasons for this. One was the lower cost; another was that local labour was difficult to understand and there was not enough time to train them. Furthermore, because the workers were usually less educated, there tended to be a bias towards their traditions, religions, etc. This attitude often led to a conflict within a work group. Thus, using Chinese labour helped lower the risk of work conflict.

5. Conflict analysis

Through the project team organization analysis identified above, we now describe and analyse the following conflicts arising within the project team organization. The structure of the organization conflict relations is show in Fig. 4.

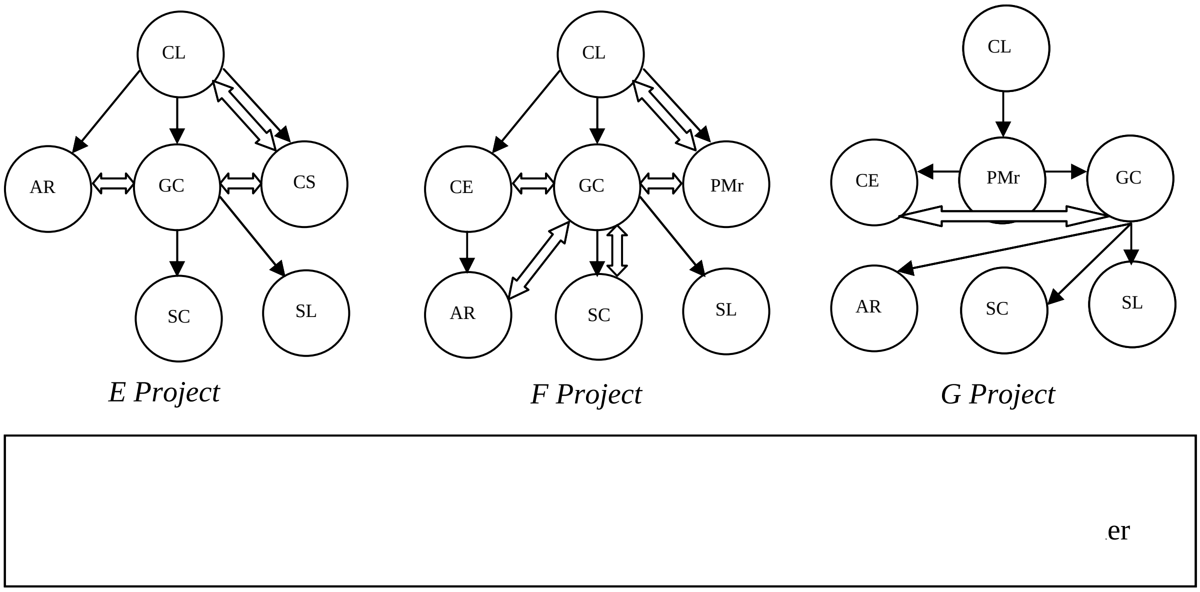

FIG.4 Conflicts within the Project Team Organization

EMPLOYMENT
CONFLICT

E Project

Japanese Client (CL) vs. Japanese General Contractor (GC)

The conflicts between the client and general contractor were due to the contractual relationship. In China, it is a fact that Japan-based contracts tend to be awarded to Japanese GCs, even though the construction cost is much higher than that of local GCs. This is because these clients believe that Japanese GCs can provide better service than Chinese GCs. Furthermore, they usually select a lump sum contract, which is based on “mutual trust”. Therefore, the client mostly relies on the GC to bear all of the responsibility, even though, according to the contract, the architect and construction supervisor are still acting as representatives of the owner. Also, the general contractor needs to appreciate client expectations, which in many cases are beyond those specified in the contract agreement. This causes conflict, but because of the ambiguity in the relationship between the client and general contractor, there is a “latent” conflict inherent to the relationship.

Japanese Client (CL) & General Contractor (GC) vs. Chinese Construction Supervisor (CS)

According to Chinese construction law, the CS is a service on behalf of the client to manage and supervise the overall activities or any specific activity of a project. CS has the power to ask the contractor to make corrections or order them to stop construction when they believe that the contractor does not conform to the design requirements. However, Japanese clients have a strong desire to withhold authority from the CS because they believe the Japanese GC’s management ability is better than that of the Chinese CS. They hire a CS only to meet Chinese law. Furthermore, as shown in Fig. 1, the CS and GC did not have a contractual relationship; the GC seldom paid much attention to or even believed in the CS’s role. During the construction process, the CS based their stance on facts and logic in their attempts to argue and oppose the GC’s arguments; on the other side, the GC refused to listen to the CS’s instructions. Consequently, a very easy problem became complicated. Because of the lack of CS’s support the project overran both cost and time.

Japanese General Contractor (GC) vs. Chinese Architect (AR)

As discussed in the project organization analysis, in G project, most of the drawings were produced by the in-house capacity. However, in China it is difficult for a foreign GC to obtain the engineering design qualification certificate. In order to meet the requirements of the law, the Japanese GC had to send the drawings to a domestic architect contracted with the client. Without the domestic architect’s modifications and judgments, the drawings could not be used for construction. Here, conflicts arose. The GC’s in-house capacity usually enhanced the concept of constructability (some techniques are widely used in Japan) with the aim of ensuring that the construction job ran as smoothly as possible and met the completion date. In contrast, the Chinese AR focused on ensuring that the drawings were in accordance with Chinese design standards. Therefore, conflicting positions on design changes became a major issue between the GC and AR.

F Project

Japanese General Contractor (GC) vs. Australian Project Manager (PMr)

In this case, the conflict between the GC and PMr were concentrated on the additional cost and design changes. The GC pointed out that the PMr did not act impartially and make fair decisions. In contrast, the PMr insisted that their decisions were all based on the FIDIC contract signed by the CL and GC. However, both the GC and PMr knew that the major issues were in terms of the contract articles. Referring to the report (Paul 2008):

“Under both the current Red and Yellow Books the Contractor’s obligation is to deliver the works that are “fit for purpose.”

“The Silver Book is recommended for use on process, power and private-infrastructure projects where the Contractor executes the Engineering, Procurement, and Construction. Risks for completion to time and quality are wholly transferred to the Contractor, the form being only suited to experienced contractors who are familiar with sophisticated risk management techniques."

A lack of understanding of FIDIC may have been the true cause behind the conflicts.

Japanese General Contractor (GC) vs. Arab Consultant and Malaysian Architect (AR)

According to the interviewees, the critical problem in the project's early stages was the inadequate flow of design information and too many misunderstandings of the design information. Delays in the production and transmission of drawings were held to be the main causes of the delay to the main frame construction. The major reasons were a lack of communication and collaboration between the GC and AR. The GC's manager noted that:

"As a reflection on this project, it seems to us that we should adjust the frame of our management organization. We defended our native (Japanese) staff excessively and ignored the importance of the local staff. For example, if we had set local staff as the assistant project manager or chief site engineer, the communication with the consultant and architect would not have been so bad."

Japanese General Contractor (GC) vs. UAE Subcontractor (SC)

Interviews with the Japanese GC revealed that both sides considered the SC&WF management as the thorniest problem. The problem was associated with the differences in religion, values, and belief systems; the concepts of contract, time, and planning; etc. In contrast to G and H projects, because of a lack of a host SC, the Japanese GC did not have enough SC to select from. Because of the high cost of Japanese labour, the Japanese GC could not bring workers from Japan.

In this case, there were two local contractor companies (one was equipment-specific, the other was garden-specific) that had previously contracted with GC, but the two contracts were terminated because of the lack of labour and rising prices. This resulted in the project's delays and extra costs.

One of B Company's project managers said, "In the UAE, there is an increased demand for manpower as the project number, size, and complexity increase. To add to this problem, the government imposes strict quotas for importing manpower from specific nations. Yet, the projects are almost all "tight schedule" projects. Local subcontractors are limited by a shortage of adequately qualified site staff. In the early construction stages, we did not hire our own workforce, but in the intermediate stages, we found that the project overran in terms of time and cost. So, we had to hire our own workers to improve the work efficiency and prepare for emergency needs."

G Project

Chinese General Contractor (GC) vs. British Consultant (AR)

In this case, the main conflicts were between the GC and AR. In contrast to the conflicts (GC vs. AR) of F project, here they were because of the design standard and material design. According to the GC's manager:

“In the UAE, the western AR prefers to use Western standards and codes, and the Chinese GC usually does not have much control over those. In order to make sure that the work met the standard, we had to spend time on understanding the standard and call the AR to confirm the work. Sometimes, we had to redo work because of mistakes in understanding. If possible, we also tried to recommend Chinese standard and codes to the AR.”

“The consultant was a Britain-based firm. They preferred to use British materials. We usually persuaded them that other materials had the same quality but a much lower price. But, they did not easily accept our advice.”

6. Summary and Conclusion

This paper presented illustrations of international project team organizations and a conflict analysis using case studies from China and the UAE. The following conclusions can be drawn from the study.

In the case of E project in China, the project team organization was rather oriented toward the general contractor, because the general contractor has a huge in-house capacity for both design and construction techniques. They were very keen to pursue the work they were responsible for to be on time with appropriate quality and cost. Although under the restrictions of Chinese design regulations, the conceptual process of a project was not carried out as effectively as in the case of the China project. Another critical factor influencing the overall project performance was the relationship with the Chinese construction superior. As a lesson, establishing a trusting partnership with the Chinese construction superior is very important for foreign clients and contractors.

For F project in the UAE, the project team organization appeared to be more complex. The organization involved participants from six countries. Such organizational complexities and other related environmental uncertainties led to delays, increased costs, and confusion among the participants. In this study, we found that Japanese general contractors were very weak in terms of contract management. For example, they did not have a full understanding of the FIDIC contract and did not carefully study the risk in the contract. These factors in turn also contributed to additional costs and time overruns. We also found that a lack of communication with the consultant and architect was a major risk to the Japanese general contractor and that it is very important to optimize the local staff’s capability. One more lesson from the study is that in the UAE, the general contractors should try to ensure a partnership with local subcontractors or prepare their own force (skilled workers) in order to deal with the labour risk.

The findings from G project indicate that Chinese contractors normally brought their own well-disciplined workforces and that the detail design was submitted by the counterpart from China. In contrast with F project, the organization was not so complex. In international projects, the Chinese contractors performed strongly by pursuing their “family” type project management, in which the general contractor, subcontractor, and material supply are all supported by their Chinese headquarters. This study will help other international contractors adjust their overseas project management strategies.

7. Limitations and Future work

As discussed above, this study was based only on a literature survey, document research, and case studies; furthermore, the case studies were limited to Japanese and Chinese. This means that the outcomes of the study were biased. Thus, the opinions and conclusions of the study cannot be regarded as popular theories. Further research is required to study the interactions in the procurement and contracting systems of different countries.

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